THE INDUSTRIAL ARTS IN ELEMENTARY EDUCATION

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INTRODUCTION

SOME thirty years ago manual training was introduced into the schools, at a time when handwork as a part of formal education was almost unknown, when industrial inefficiency on the part of school-trained individuals was the rule. It was hailed as a panacea; its effectiveness was not then questioned by anyone; today its value as an all important means to industrial efficiency is questioned universally. Out of thirty years of trial, error and success there has at last been evolved a logical conception of manual training and its function in the curriculum. Briefly, the progressive steps in this evolution have been: (1) The introduction of manual training as a form of disciplinary activity. (2) The elevating of manual training to the rank of a school study. (3) The consciousness that manual training did not produce efficient workers, thinking workers. (4) The conviction that manual training being decidedly lacking in content values and therefore, in no way equal to other content studies, should no longer be entitled to recognition as a school subject. (5) A more serious contemplation of industry, with a view to providing a school study of maximum educational worth-which should deal with industry as an organized body of human experience.

As we look back over this growth in the conception of a school study we wonder that advancement has been so slow. Industry from the first demanded of education that it be made industrial, not merely that it be made manual. The result of our inability to understand the demands made by industry has been that manual activities have flooded our schools; manual activities, activities specifically manual and decidedly unindustrial. School courses have been limited to one or two materials, easily obtained and easily worked, because teachers have persisted in holding fast to the old exploded theory that the acquisition of skill should be the ultimate aim of all industrial courses.

In a word, the selection of activities has been made upon the basis of materials at hand, rather than upon the industries. Whenever courses have been thus built they have failed, in that they have emphasized activities unduly and have thus made them ends in themselves rather than means to ends. In such courses tool processes have been the determining factor both as regards the choice of projects and their arrangement in the course.

What elementary schools need most today is not a period now and then devoted to manual training. It is, of course, true that pupils in the grades should have manual tasks to perform, but this handwork need not be relegated to a period now and then devoted to manual work, and there divested of a large part if not all of its original educative significance. What the elementary school does need more than it needs this kind of manual training is a comprehensive course in industries.

There is a vast body of industrial content material with which all men and women of true culture should be familiar. This material is today being collected, organized, and evaluated, and it is gradually being crystallized into a new school study. What this study is called makes little difference. We choose to call it industrial arts. Professor F. G. Bonser of Columbia University, has defined industrial arts as the distilled experience of man in his resolution of natural materials to his needs for creature comfort, to the end that he may more richly live his spiritual life. If we accept this definition and govern ourselves accordingly we shall provide for a school subject which will deal primarily with the industries, a study of industry from the social side as well as from the material side, a cultural study of industry with the emphasis upon the how and why of industrial operations combined with a real appreciation of industrial life.

The industrial arts point of view accepted, we shall see that for the purpose of organization most of the drawing and construction work done in the elementary schools will fall to the subject of industrial arts, not because industrial arts is a *manual* subject but rather because it is an *industrial* subject and because industry deals more with activities than do history or geography or arithmetic. As phases of school life, drawing and manual training are at the disposal of all school studies, but the time has gone by when drawing and manual training should be regarded as subjects in the elementary school.

In the preparation of this book the authors have had in mind two classes of people, (1) teachers engaged in instruction in the elementary grades, and (2) students in normal schools and colleges who are preparing to become elementary teachers. In the first instance the book will be a reference work, and in the second, a text to be used in elementary industrial arts courses. Under the general term *industrial arts* we include all of those phases of handwork and industry study commonly known as manual training, manual arts, drawing, construction work, art work, etc. Our chief aim is a presentation of the study of industrial processes and materials, and all handwork introduced will be chosen with a view to giving familiarity with these materials and to making clearer processes through participation in the activities.

The study is approached from the standpoint of general education, the activities involved being adjusted to the ability of the various grades. The subject matter will be chosen from the industries most important to man, the products of which may be arranged in the following groups:

I. Stone, Clay and Glass Products.
II. Metals, Machinery and Conveyances.
III. Wood Manufactures.
IV. Furs, Leather and Rubber Goods.
V. Chemicals, Oils and Paints.
VI. Paper and Paper Products.
VII. Books and Printed Products.

VIII. Textiles and Clothing.
IX. Foods.
X. Water, Light and Power.

The handwork recommended is based entirely upon the industries studied and is of two kinds: (1) drawing, including representation and design, (2) construction, including the preparation and combination of materials.

The industry once decided upon, the class is put to work investigating it, collecting information from all the sources available. Much of the material will be obtained through actual contact with those engaged in the industry or who handle its products. Some facts will have to be obtained from reference books. Students will also be able to collect information by writing to manufacturing concerns whose advertisements they see in the magazines and newspapers. The instructor should make assignments covering such topics as the following: (1) The value of the industry to man. (How we are affected by it.) (2) The evolution of the industry; its heroes of invention. (3) Characteristics of the product. (4) Analysis of the product. (5) Materials employed. (6) Processes involved. (7) Classification of processes as skilled and unskilled. (8) Healthfulness. (9) Hours and wages. (10) The training of the workers. (11) The part played in the industry by mathematics. (12) The part played by drawing. (13) References to the industry found in literature. (14) The industry as depicted in art.

Projects illustrative of the industrial processes involved in the above study are arranged by the instructor who is careful to assign them as problems to be solved, each student being allowed, wherever possible, to work out his own dimensions from the instructions given.

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CHAPTER I.

STONE, CLAY AND GLASS PRODUCTS

CONCRETE CONSTRUCTION

WE hear a great deal nowadays about concrete construction; a long list of things ranging from sidewalks and fence posts to great buildings, dams, and bridges are built of it. Its use as a constructive material dates from ancient times. The Romans at the beginning of the Christian era were perhaps as extensive users of it as we are today. The ancients, however, employed a natural cement, whereas we use a manufactured product. The popularity of concrete as a building material is due to the following factors: cheapness, convenience, durability, strength in compression, and fire resisting qualities. For building purposes, concrete is superior to most varieties of stone both in compression strength and in durability, while stone is far more expensive. The use of concrete is replacing that of timber in many industries, a fact which is due chiefly to the scarcity and resulting increase in the value of timber.

Three materials are used in the making of concrete: (1) The *matrix* or binding agent which is generally Portland cement, so named by its originator, Joseph Aspdin (1824) of Leeds, England, because of its resemblance to the cliffs at Portland, England. (2) The *aggregate*, which consists of the hard materials such as broken stone, gravel and sand. (3) *Water*.

The principal ingredients of Portland cement (the matrix) are lime, silica, iron and alumina. They are obtained from rocks which are mined or quarried as the conditions require.* The rocks are crushed in a powerful jaw crusher, and the crushed stone pulverized in a ball mill, consisting of a cylindrical drum which revolves in a vertical plane. The process of grinding is accomplished by means of balls of hardened steel, which tumble and roll among the pieces of rock as the cylinder revolves. Seldom, if ever, are rocks found which contain all the constituents of Portland cement; if lime is lacking in the cement rock, lime stone is added to the ground rock; if alumina is lacking, it is furnished in the form of shale, etc.

When partially ground, the materials are properly proportioned and are thoroughly mixed by being ground together. The resulting fine powder, known technically as the raw mixture, is fired in a cement kiln, a great tube, cylindrical in form, which is constructed of boiler iron and lined with fire clay. The kiln lies in a nearly horizontal position, being slightly elevated at the receiving end. The raw mixture enters the kiln at a hopper, which is attached to the elevated

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* Marl or river mud also furnishes materials for the manufacture of Portland cement.

end, while the cylinder revolves laterally just as a pencil revolves when twirled between the fingers. Cement kilns are from 6 to 10 feet in diameter and from 60 to 200 feet in length. They are revolved by means of huge gears which, extending entirely around the kiln, mesh with smaller driving gear wheels, while the tube rests upon riding wheels resembling large casters. An intense heat of from 2,500 to 3,000 degrees Fahrenheit is maintained in the kiln by the combustion of powdered coal which is blown into it at the lower, or discharging end, by a forced draft. As the small particles of raw material gradually roll down through the revolving tube of the kiln, they are burned, or *calcined* as the cement maker puts it, to clinker, and are dropped out at the lower end. The clinker comes out in the form of little balls which are about three-eighths of an inch in diameter. Their surfaces are rough but they are quite round and uniform in size.

When the clinker has cooled sufficiently, it is reduced once more in a ball mill. This time it is ground so fine that the powder will pass through a screen with 40,000 holes to the square inch. This finely ground powder is our finished Portland cement of commerce.

When the first Portland cement was made in England along the banks of the river Thames, it was fired in a stationary kiln. The making of a single batch of cement then required about twenty-four days. Today the process is continuous and many hundreds of barrels are turned out every twenty-four hours.

The aggregate used in the making of concrete consists of large stones and sand. In practical work all stones which will pass through a sieve with four meshes to the linear inch are considered sand. The materials must be clean and hard. Sand which is too fine or which contains over five per cent. of vegetable matter or loam will not produce good concrete. It should not be used.

In order to test the sand and to determine if it is clean enough for use one may take a common one-quart glass fruit jar and place in it four inches of the sand to be tested. Water is poured in until it reaches to within three inches of the mouth of the jar. The jar is now covered and is shaken vigorously until the sand is entirely suspended in the water. The mixture is allowed to settle until the water has cleared. If, after the water has cleared, the layer of loam which has been deposited above the sand is one-half inch thick the sand is not fit to use.

The best results in concrete work will be obtained when various sizes of sand and stone are used. The small aggregates will then fit into the voids formed between the larger ones and a compact or dense mass produced.

The water used should be free from all impurities which would tend to injure its action upon the cement. Moderately warm water

will hasten the hardening of concrete while extremely cold water retards the hardening. The hardening of concrete is called *setting*. It is a chemical process.

Concrete is molded when soft, into appropriate shapes by the use of forms, which must be made tight enough at their joints to prevent the mixture from running out as it is poured into them in a semi-liquid state. The forms should be adequately braced and tied to prevent the pressure of the materials from spreading them. Nearly all forms are made from wood, although iron and steel are coming to be used in the making of forms which are used over and over again. In the building of foundations, trenches are dug and the walls of earth thus provided are utilized as forms below the ground. In the making of concrete pottery and small articles, plaster-of-Paris forms are sometimes used.

Concrete structures are often reinforced in order to strengthen them; especially is this done where they must withstand tensile strain. The kind of reinforcing and its placing depends upon the shape of the structure and the location of the strains to which it is likely to be subjected. Small structures are reinforced by the imbedding of wires in them while the material is being poured. For heavier work, coarse iron bars and even steel girders are used.

If the best results are to be obtained, concrete must be mixed thoroughly. The purpose of mixing is to get the smaller aggregates to fill the voids between the larger ones in order that a dense mass may be produced, and to provide that each particle of aggregate may be entirely coated over with a thin covering of cement which will cause it to adhere to those about it. Each tiny grain of cement must be thoroughly wet if an efficient hardening is to be obtained, a *setting* which will bind the whole mass together into a compact, stonelike conglomerate. The setting of concrete involves chemical action. It is not a drying process, quite the reverse. Drying must be prevented until setting is accomplished.

When concrete is to be mixed by hand, a large mixing platform constructed of planks is used. The platform is provided with strips nailed to its edges to keep the liquid mixture from running off. The fine aggregate and the cement are first mixed dry and then water is added slowly as the process of mixing is going on. The coarse aggregate is then wetted and is mixed with the fine materials.

When concrete is not mixed by hand the mixing is generally accomplished by means of a rotary batch mixer, a power-driven machine which consists of a barrel into which the materials are poured by means of a hopper. They are first mixed dry and then the water is turned in. The barrel is revolved until all the materials are thoroughly combined. The following are some of the standard concrete mixtures: (The first figure indicates the number of parts of cement; the second,

FIG. 1 Sand filling voids of large stone.

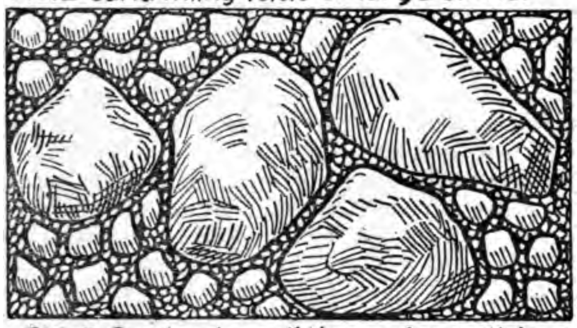

FIG. 2 Sand and small stone mixed with large.

FIG. 3 Mixture of graded stone and sand.

the number of parts of fine aggregate; the third, the number of parts of coarse aggregate). Rich mixture, 1:2:3, used in watertight utensils and in places where there are high stresses. Standard mixture, 1:2:4, used in machinery foundations and in floors. Medium mixture, 1:2½:3, used in retaining walls, sidewalks and similar structures. Lean mixture, 1:3:6, used in heavy walls and in large work generally.

Just what takes place when concrete sets is not definitely known, but we do know that the bond continues to strengthen for a long time after the material has had its initial or first hardening. It will stand a much heavier load after it is a year old than when only a month old. How long this gain in strength continues is yet to be determined by the scientist.

POTTERY

Since clay, when mixed with water, can be worked into various shapes on account of its doughlike condition and can be hardened by means of fire, it has been utilized by most primitive peoples in the potter's craft. Clay is made up of minute particles which are held together by aggregation when moist but which are easily separated when dry. If we add to clay an excess of water we shall find that the small particles will be so suspended in the water that they will appear to be dissolved. Besides the free water which clay contains, it also possesses a small amount of water in chemical combination which, when once expelled by fire, cannot be replaced. Thus sun-dried or *adobe* bricks are not practical in a moist climate, while burnt bricks, when exposed to the weather, are practically imperishable. Clay once burnt never regains its plasticity.

Clay is found in all stages of purity. Often it is combined with an excess of sand, iron, or vegetable matter so that it is not fit for use in making pottery. Kaolin is the purest form in which it is found. Ball clay and stoneware clay are used extensively in the making of dishes.

Various means have been devised for separating clay from its impurities. Most of these depend upon the principle that the clay can be suspended in water and thus carried away from other substances which are heavier and therefore sink.

Pottery may be divided into three general classes: (1) Earthware, the coarsest kind of pottery. The common red flower pot is an example. This ware is opaque and sticks to the tongue. It is so soft that it can be scratched with a knife. A low temperature is sufficient for its firing; a greater heat would melt the clay to a mass. (2) Stoneware, a hard, vitrified, ware fired at a higher temperature. Ordinary table ware, which is not translucent, is an example. (3) Porcelain, a translucent pottery of the highest quality made from kaolin. All china dishes are examples of porcelain.

The most primitive method of making pottery is by the hand method of building. Coils of clay are wound around, one on top of the other, and welded together by pressing, and sometimes by the use of water. A dish is shaped and smoothed by hand.

When vessels of circular form are to be made the wheel throwing method is often employed. In this method the lump of clay is placed on a revolving horizontal disk and shaped by the hands of the potter, who keeps his hands moist by dipping them constantly into a thin mixture of clay and water which is called slip. By means of the slip his hands are kept from sticking to the revolving lump of clay. After the vessel has been removed from the disk and has become partially dry, the form is often perfected by means of turning. Handles and spouts are put on the vessels before firing by sticking them on with slip while the parts are still moist. Jiggers and jollies are special devices attached to potters' wheels and used in making tall and flat dishes. By their use the potter is able to make all of his vases alike, the jiggers and jollies remaining stationary while the form revolves.

Casting is used when pottery of a high quality is desired and when the walls are to be very thin. The clay is thoroughly suspended in water in the form of a slip which is poured into a plaster-of-Paris mold. The plaster-of-Paris absorbs the water, thus causing a thin coat of clay to be deposited all around on the inside of the mold. When the deposit is thick enough to form the walls of the vase, the remaining slip is poured out leaving the wet piece of pottery on the inside of the form. After this partially dries and shrinks somewhat, the mold is removed. When the dish becomes thoroughly dry it is finished by hand and prepared for firing.

It is placed in a *kiln* which is a box-like structure built of fireclay bricks and surrounded by flues in order that the fire may entirely surround the dishes and yet not actually come in contact with them, as the smoke would discolor the ware. Most dishes are fired twice. The first firing is called the biscuit firing and the piece of pottery once fired is called a biscuit piece.

After the biscuit has been fired it is *glazed*. A glaze is a glassy covering placed on wares to beautify them and to make them more serviceable. Glazes usually contain a metallic element which gives them their color. Iron oxide gives red; copper oxide, green; cobalt, blue, etc. Glazes also contain silica, the material which furnishes the glass proper, and alumina. The biscuit is submerged in water and is then dipped into the glaze mixture which consists of the above named constituents ground in water and mixed with gum arabic and gum tragacanth. The gums act as a glue and fasten the powdered glaze to the biscuit until the fire vitrifies or melts the mixture into glass.

Dishes are often decorated by the use of colored glazes and also by the use of overglaze colors, as in the case of china painting. Good

designs are always well adapted to a flat surface and are therefore not naturalistic but conventional. They should always emphasize the structure of the dish. In other words, the dish should be made to look stronger because of its decoration. If the decoration does not accomplish this end it had better be omitted.

THE BRICK AND TILE INDUSTRY

A brick is a rock-like substance which has been shaped into a form convenient for laying into a wall. The native clay brick is confined to those localities where material suitable for its manufacture is found. For this reason the industry is sporadic in the United States. Pennsylvania ranks first among the states in the production of brick and tile, and Ohio, Illinois, New York and New Jersey, follow in the order named. The fact that brick and tile are permanent as building materials is demonstrated by the excellent state of preservation in which the old buildings of Europe built of these materials are still found. Bricks found at Bismaya, in the Euphrates Valley in Asia, are still in as good a condition as they were when made forty-five hundred years before our era. Brick is the oldest artificial building material known to man. From the earliest pre-historic times the inhabitants of ancient Samaria, of Chaldea and of Egypt built houses of sun-dried brick, *adobe*. We find that the kings of Chaldea and the Pharaohs of Egypt lived in brick houses, and that Nebuchadnezzar, King of Babylon, built his palaces and temples of this material.

Concerning the modern application of brick, however, Rome seems to have been our teacher, for the remains of extensive Roman brick work are found in Europe as well as in the far east.

Brick can lay claim to a world-wide use in medieval times. For not only can China, India, Persia, Babylon, Egypt, Greece and Rome in the old world boast of their ancient brick remains, but the western world had long practiced the art. It was during the thirteenth century that the brick industry as we know it today began to flourish in the north of Europe.

When the Spaniards came to America they found among the Incas and Aztecs buildings and monuments built of brick.

In the early days of the American colonies, small quantities of brick were imported, and some of the brick probably was brought in the bottoms of ships as ballast. The first brick houses erected in America were built of bricks imported from abroad. Statistics from Ries and Leighton indicate the beginning of the clay working industries in the United States as follows: Virginia, in 1611; Massachusetts and New York, 1629; Maine, 1635; North Carolina, 1663; Rhode Island, 1680; and Pennsylvania, 1683.

The kinds of brick and tile made today are:

Brick—	Tile—
1. Common.	1. Drain.
2. Face.	2. Sewer.
3. Paving.	3. Roofing.
4. Enamel.	4. Decorative, for walls and floors.
5. Fire.	5. Building.

The manufacture of "hand-made" bricks may be divided into two stages: (1) Preparation of the raw material, involving the operations of *washing, tempering*, and *pugging*, and (2) the formation of bricks from this raw material, involving the operations of *molding, drying*, and *firing*.

Washing is introduced to separate stones and other foreign matter from the clay, and is done in a wash-mill. This consists of a large tank, about fourteen feet in diameter, in which a set of paddles revolve at the rate of nine or ten times a minute. The churning causes the clay to mix with the water and to form a kind of slip or slurry which is run off, while the stones sink to the bottom of the tank. From twenty to forty cubic yards of material can be thus washed in one of these mills in a day.

But sometimes the clay is obtained in the form of shale and it is often very hard and lumpy. It must then be crushed before it is mixed with water. This crushing is accomplished in a pan-mill, with edge rollers. A pan-mill consists of a cast-iron pan, six to eight feet in diameter and perhaps two feet deep, in which a pair of rollers mounted on a horizontal shaft are caused to turn. The shaft is rotated about an axis through the center of the pan perpendicular to itself, thus causing the rollers to move in a circle around the inside of the pan. These rollers are called edge rollers because they have a narrow tread which provides a cutting action in the crushing of the shale. Much of the grinding and crushing may be avoided, however, by exposing the clay to the action of the weather for a sufficient length of time before an attempt is made to work it.

After the clay has been washed it is tempered. The operation of tempering consists in mixing water with the clay and working the two together until a paste of a fairly uniform consistency is formed. Best results are to be obtained by doing this a couple of days before the clay is to be pugged.

Pugging is a further process of mixing and is employed to reduce the clay to a homogeneous, plastic mass. This operation is accomplished in a pug-mill, which usually consists of a vertical cylinder with a vertical shaft, to which are attached knives which revolve about the shaft, in its center. Tempered clay is thrown in at the top and is

cut and mixed by the knives as it works its way down through the cylinder, until it is finally discharged at the bottom, thoroughly pugged and ready for molding.

Two methods of molding bricks by hand are in use; *slop molding* and *sand molding*. In the first method the workman forms a lump of clay to approximately the size and shape of a brick and then dashes it into a mold, which has been dipped into water so as to wet the inside of it thoroughly. He then compresses the clay in the mold so that it fills it completely, using a rammer, called a *plane*, which is simply a small flat board with a handle set perpendicular to the board in the center of it. The superfluous clay is removed and an even surface produced by drawing a straight-edged strip of wood, called a *strike*, across the top of the mold. The mold, with its contents, is then carried to the drying floor and the brick turned out on the floor.

Sand molding is very similar to slop molding, except that in the sand method the mold is dipped into sand instead of water, so that a coating of sand is deposited on the inside of the mold. The purpose of the dipping in both cases is to prevent the clay from sticking to the mold.

Hand molding is rapidly being replaced by machine molding, however. In molding by machine the clay is placed in a large cylindrical tank into one end of which a piston is forced, which causes the clay to be squeezed out at the other end of the cylinder through a rectangular shaped opening, equal in size to the larger horizontal cross-section of a brick. The clay comes out in the form of a continuous rectangular bar and is deposited on the cutting table. Here a frame carrying a number of wires spaced as far apart as the thickness of the brick is drawn down on the bar of clay, and the wires passing through it divide it into bricks. Bricks manufactured by this method are called *wire-cut* bricks.

The bricks must be thoroughly dried before they can be fired in the kiln because the moisture contained in them would produce an excess amount of steam and cause them to explode when subjected to the heat of the kiln. They are placed in racks, one tier above another and are set on edge in rows and spaced about five inches apart in order that the air may circulate around them. These racks are covered with a roof-like structure of boards to protect the bricks from the rain; or the racks may be inclosed in sheds. When the bricks have dried sufficiently to be handled without danger of distorting the shape, they are *skintled*, or set still farther apart and placed diagonally to allow the air to pass between them more freely.

When thoroughly dry they are fired in a kiln (the more modern way) or in a *clamp*. A clamp is formed by piling bricks so that there are passages through it in which fuel is placed. Other larger passages extending through to the outside are left to serve as flues. The

fuel used consists of cinders or of coke distributed in the interior passages. The flues are filled with fagots which are lighted from the outside and which soon ignite the adjacent coke inside. The fagots are kept burning for a day or so and are then removed and the mouths of the flues stopped with bricks and plastered over with clay. The clamp is allowed to burn until the whole of the interior fuel is consumed, which usually takes from three to six weeks. The clamps are then torn down, the bricks sorted, and piled ready for shipment.

A modern brick kiln is a large oven-like structure built of fire-brick, with an arched roof and a tall stack for creating the necessary draft for firing. The bricks to be fired are piled in it in such a manner that the burning gases from the fire may circulate between them. The fuel used in the fire-box of the kiln is generally bituminous coal, which, when burned, liberates a gas which is itself burned within the kiln chamber. Two kinds of kilns are used, an *up-draft* and a *down-draft.* In the up-draft type the flame is allowed to pass directly up through the brick from bottom to the top of the kiln, while in the down-draft furnace, the flame does not come in contact with the brick until it has first reached the top, when it pours down through the brick to the flues. A temperature of 1,200 degrees Fahrenheit is maintained.

Roofing tiles are usually made from a high grade of red clay that burns to a scarlet color. It is necessary that these tiles be not porous. They are therefore fired at a higher temperature than common bricks.

THE GLASS INDUSTRY

Glass has been used by mankind, both in the making of useful articles and of ornaments, since the dawn of civilization. We find that the Egyptians made glass articles as early as 4,000 years B. C., and that glass shops were operated extensively in the ancient cities of Tyre and Sidon. The Phoenicians were the first people to make mirrors. They also used manganese in making glass clear. We know that the people of Assyria and Babylonia were skilled in the glass industry, for a bowl made of green glass bearing the name of King Sargon (772 B. C.) is now exhibited in the British Museum. The use of enameled brick and transparent glass of different colors, in wall decorations for temples and public buildings, was quite extensive in Persia. The Chinese also claim a very early knowledge of the glass industry. It is asserted among the Chinese that glass and even lenses were made as early as 2,000 B. C.

After Constantine had removed the capital of the Roman Empire to Bazantium, in A. D. 330, he established numerous glass factories in his kingdom. The glass produced was of the best quality made up to that time. The craftsmen whom he employed were artisans who came from fallen Rome to resume their trade. France, Germany

and England acquired the art of glass making from the Romans at a very early date.

The earliest glass articles were practically all of an ornamental character, being substitutes for precious stones, or were used for other ornamental purposes such as decorations for buildings, etc. These were generally molded, although we do find some glass blowers among the early Egyptian craftsmen. The earliest glass molding was done in much the same way as metal castings are molded today.

Glass is made in many different ways by the use of a variety of chemicals; but in its simplest form, its constituents are glass sand, or silica; alkali, or soda ash; and lime. The industry, therefore, thrives best where these materials are most easily obtained. Glass sand, the principal ingredient, is found in Pennsylvania, Ohio, Illinois, West Virginia, New Jersey, Missouri, and in other states of the Union. The industry is carried on most successfully in those parts of the country where there is an abundant supply of natural gas, this being a cheap and desirable fuel for the melting of the raw materials.

The United States ranks among the leading countries of the world in the production of glass, but because a great portion of it is utilized at home little is left to be exported. Other countries which produce the most glass are Belgium, Austria, Germany and France.

Several different kinds of glass are made at the present time, the two principal ones being lime glass, which is a compound of silica, soda ash and lime, and lead glass, which is a compound of silica, soda ash and lead. The lime glass is much harder than lead glass and most of the cheap grades are therefore made of lime. Lead glass is clearer and more brilliant and being softer is often cut. Our most beautiful articles of clear glass, including cut glass, are therefore made of lead. Practically all colors are obtained in glass, variation in color being produced by adding salts of metal, as iron, to produce red, copper, to produce green, and cobalt, to produce blue, etc.

The raw materials for glass making are ground to a fine powder called *glass batch*, or *frit*. The grinding is done in a ball mill similar to that used in grinding the raw materials used in the manufacturing of Portland cement.

The ground materials are mixed and then placed in a melting pot or crucible made from fire clay. A temperature of 3,000 degrees Fahrenheit is required to fuse the materials. After thorough melting and mixing the glass is produced.

Another important process in glass making is annealing. Annealing is done to prevent brittleness. Two methods are used; the slow heating of the ware in a kiln, or the more rapid method of heating it in an annealing lehr or oven through which the glass passes on a slowly moving carrier. The first method may require several days, while the second requires only a few hours.

The glass blowers take their iron tubes, which are about five feet long, and dip them into the molten material, which is now called *metal*. A quantity of the metal collects on the glass blower's tube as he revolves it in the mass. It is then removed and blown into the shape desired. Molds of clay or iron are often used in shaping the articles of glass, the molten glass being blown into the mold. In some cases, however, the glass is not blown but is shaped by pressing into the molds. In making plate glass molten glass is poured upon a large, smooth iron table. A huge roller is passed over the mass, rolling it out into a thin sheet of even thickness. When the glass has become cool it is ground and polished.

In making window glass the metal is blown into a large bulb. This bulb is then rolled into a cylindrical form, is cut open and finally flattened out.

Cut glass is another popular product of the glass maker's skill. The dish or vase form which is to be decorated by cutting is made by pressing, or by blowing, the molten glass into the desired shape, using a mold of iron. The glass cutter then cuts the decoration into the glass by pressing the dish against a revolving grinding wheel which is fed with emery powder and water. Cut glass, however, is not in good repute among people of taste. The process of cutting is not always appropriate to glass forms. It also renders the forms unpleasant to handle. Cut glass dishes are often decidedly weakened by the cutting and are more liable to crack when subjected to quick changes of temperature, as in washing. Besides this method of ornamenting glass, beautiful designs are also obtained by staining or painting and reheating, and by etching with hydrofluoric acid.

The following is a list of articles made of glass:

(a) Blown Glass	Window Glass
Bottles	(b) Mirrors
Bulbs	(c) Cut and Ornamental Glass
Chimneys	Stained Glass
Crown Glass	Table Wares
Flasks	Tumblers, etc.
Insulators	Tubes
Jars	Wire Glass

The glass industry is very important, as can be seen from the fact that the uses of glass are innumerable. Without glass we would have no sunlight in our homes, no mirrors in which to see ourselves; other kinds of table wares would have to be used; in fact, we would have to be inconvenienced in a variety of ways were it not for glass. Indeed, only when we think of the many different things for which glass is used and the number of people that find employment in the making of glass do we really appreciate the industry.

CHAPTER II.

METALS AND METAL PRODUCTS

IRON AND STEEL

IRON exists in nature as ore, which is a combination of iron and other elements in the form of rock or earth. The only ores from which iron is manufactured in large quantities are those containing the oxides and carbonates of iron. The most modern method of mining iron ore is known as open pit mining, which is indeed more in the nature of quarrying than of mining in the ordinary sense, the ore being scooped from the surface of the ground by huge steam shovels. The mining of the Lake Superior region is done by this method. All the handling is done by machinery, the ore being loaded directly upon the cars for transportation to the receiving bins at the wharves, or to the chutes leading to the waiting boats. When the ore is gotten from the pit in pieces too large for convenient handling (as is often the case) it is run through a crusher before being delivered to the cars.

Iron in the metallic form is extracted from the ores by the action of heat, the process being known as *reduction.* This is done in a furnace known as the blast furnace, which is a tall, slightly tapering shell made of iron plates and lined with fire bricks. These shells vary from twenty to a hundred or more feet in height, and are about fifteen feet in diameter. The ore, along with the fuel (coke) and a flux (limestone) are poured into the furnace through a hole in the top which is closed by a large movable lid called the bell. This *charging* is done entirely by machinery, the materials being carried to the top of the furnace by elevators, and unloaded automatically into the furnace at the proper time. A blast of hot air is blown into the furnace at the bottom and passes up through the ore and out at the top in the form of a gas which is further used for fuel or for the generation of power. The ore, entering at the top, is first exposed to the lower temperatures which are sufficient to dry it and drive off the volatile substances. As the charge descends in the blast furnace it is subjected to higher and higher temperatures which cause the oxygen of the ore to combine with the carbon and carbon monoxide present, thus leaving the iron chemically free and in a molten state as it reaches the bottom of the furnace. In the older method of blast furnace operation the molten iron was removed through a tap hole at the bottom of the furnace and run into trenches or molds in the sand floor around the furnace, where it was allowed to cool, and was then known as *pig iron.* In more modern smelting works the molten metal from the furnace is discharged directly into iron molds attached to an endless chain, which carries it to a point where it is cooled either by being sprayed with water or by actually passing through a tank of water.

Where the contents of the blast furnace are to be converted into steel at once the molten metal is carried in movable tanks directly to the steel furnaces. The metal is poured from the tanks into a mixer, in which the products of the various furnaces are mixed to insure uniformity of quality. From the mixer the metal is transferred to the *Bessemer converter*. This converter is a barrel-shaped structure suspended vertically by trunnions at the middle, and having an opening at the top. The molten metal from the mixer is poured through the top and a blast of cold air is blown in at the bottom which passes up through the molten metal and out at the top in a roaring flame which is red at first, but which gradually changes to white and then to a weak, light blue. These changes of color indicate changes in the metal, and the appearance of a certain tint of blue indicates that the conversion into steel is complete and the air blast is then shut off. The contents of the converter may now be drawn off as liquid steel into molds of any desired shape and size, and when cooled the steel is ready for shipment. In the large steel plants, however, the metal is not allowed to cool, but is sent direct to the rolling mills, being drawn off from the converter into *ingot molds* mounted on small cars. When the metal has cooled sufficiently to set, these molds are removed and the glowing *ingots* are ready for shaping by machinery in the rolling mills.

The rolling mill is an establishment provided with machinery for working metal ingots into rails, bars, plates, rods, and other structural shapes, by repeatedly passing them, when intensely hot between cylindrical rolls. These rolls work in pairs, one above the other, and are of such contour that they will impart the desired shape to the metal ingot passing between them. The operation is continuous through these pairs of rolls, each succeeding pair causing the ingot to be lengthened and to more nearly approach the desired cross-sectional shape.

Not all of the product of the blast furnace goes to the Bessemer converter to be made into steel, however. Much of the *pig iron* produced by the blast furnace is sent to the foundry where it is cast into machine parts by the use of sand molds. "*Founding* or metal-casting is the art of forming in loam or sand a mold of any given design, which is subsequently filled with molten metal and allowed to solidify." Iron founding may be divided into three operations, (1) the making of the mold, (2) the melting of the metal, (3) the pouring of the metal into the mold.

The process of molding in sand, using *flasks*, may be described as follows: The lower flask, called the *drag*, is filled with damp sand and the lower half of the pattern imbedded in it. The upper flask, or *cope*, is then placed in position on the lower, and sand is rammed tightly around the lower half of the pattern. The pair of flasks is then turned bottom up, and the sand first loosely placed in the drag, is

removed. A thin layer of dry *parting sand* is sprinkled over the sand in the cope and then the drag is refilled with sand and firmly packed. The flasks are now reversed to the original position and separated, the parting sand making it possible to separate the two bodies of molding sand. The pattern is then removed and any imperfections of the mold are remedied by hand, and the two flasks are again placed together in position. The molten metal is now poured into the mold through suitable passages, called *gates*, which are cut in the parting surface of the sand from the edge of the mold to a vertical hole called a *sprue pin hole*, provided by inserting a sprue pin in the sand when it was packed around the pattern.

The iron is melted in a *cupola*, or foundry furnace, which consists essentially of a short iron cylinder mounted on iron columns and lined with fire-brick, and surrounded near the bottom by a belt or wind box from which pipes or nozzles called *tuyeres* extend into the cupola and give entrance to the air blast. Cupolas vary in inside diameter from 22 to 100 inches. They are cylindrical for a portion of their height and then taper to a cone to form a chimney. The charging hole is placed at the top of the cylindrical portion, and at the bottom are breast holes for raking out the cinders, and a tap-hole through which the molten metal is withdrawn. The metal is run into ladles, which are iron vessels lined with a refractory material and provided with a lip for directing the metal when poured into the mold.

Wrought iron can be produced either from the ore directly, or by the conversion of pig iron in a reverberatory puddling furnace. In the latter process, known as *puddling*, white pig iron is melted and subjected to an oxidizing flame until the carbon is burned out or becomes less than 0.25 per cent. The puddling furnace is usually a single bedded reverberatory furnace made of cast-iron plates and lined with fire-brick. This furnace consists of a combination chamber oblong in shape. At the front of this chamber is found a grate-bar, to the rear of which rises a vertical wall, and back of this, at a higher level than the grate bars, is a shallow receptacle, or hearth, for the charge. The roof covering these two chambers is horizontal over the grate-bars but curves downward as it extends back, until at the flue entrance it is below the level of the charge. There are two doors at the side, one for feeding the fire and the other to give access to the charge. The combustion of the fuel takes place on the grate-bars, and the hot gases rise to the roof and are beaten back, or reverberated upon the charge, as they move toward the flue. The iron is heated until it melts into a thick fluid mass. While in this condition it is thoroughly stirred and worked by means of a long iron bar, to insure all parts of the iron being treated. This working is called the *rabbling*. The puddling process is carried on at a high temperature with the iron in a semi-fluid

state; it causes most of the impurities to be burned out or else separated as slag. When the process is nearly completed the iron becomes thicker and is known as a *mat*. The workman divides this mat into masses of about 160 pounds each, and with his bar rolls them into balls on the hearth of the furnace. A small amount of slag will adhere to the balls and be rolled up in them. To get rid of this slag the balls are removed from the furnace and passed through a squeezer, which is a form of press that forces out the slag and welds the iron into a solid mass, after which it is passed through rolls and reduced to the form of bars. It is then known as wrought iron and is ready for shipment.

LEAD

Lead is a metallic chemical element, but occurs in nature in the metallic state very rarely, and then only in minute amounts. The chief lead ores are galena and cerussite. Galena, the principal lead ore, has a world-wide distribution, but is always contaminated with silver sulphide. The principal English lead mines are in Derbyshire. The Welsh mines are chiefly in Flint, Cardigan and Montgomery shires. On the Continent the most important mines are those in Saxony and in the Harz, Germany; those of Carinthia, Austria, and especially those of the southern provinces of Spain. Lead is found in Tunisia and Algeria, in India, and in New South Wales, Queensland, and in Tasmania. It is widely distributed in the United States and occurs also in Mexico and Brazil.

The United States produces more lead annually than any other nation. In America the most important regions are those of Colorado and Nevada. The Nevada mines are mostly grouped around the city of Eureka, where the ore occurs in *pockets* disseminated at random through limestone. The Colorado lead district is in the Rocky Mountains, a few miles from the source of the Arkansas river. The discovery of the ore here was the making of the city of Leadville, which in 1878, within a year of its foundation, had attained a population of over 10,000 inhabitants. The ore occurs here in gigantic deposits of almost constant thickness, embedded between a floor of limestone and a roof of porphyry. The Leadville ore contains 24 to 42 per cent. of lead and 0.1 to 2 per cent. of silver. The Nevada ore contains about 30 per cent. lead and 0.2 to 0.3 per cent. silver. The production of the different countries is given below. (Figures indicate tons of lead):

Country—	1850	1900	1905
United States	20,000	253,000	319,744
Spain	47,000	176,000	179,000
Germany	12,000	120,000	152,590

Country —	1850	1900	1905
Australia	....	68,000	120,000
Canada	....	28,654	25,391
England	66,000	35,000	25,000
Italy	....	20,000	25,000

The extraction of the metal from the pure (or nearly pure) galena is the simplest of all metallurgical operations. The ore is roasted (*i. e.*, heated in the presence of atmospheric oxygen) until all the sulphur is burned away. The first effect of the roasting is the elimination of sulphur as sulphur-dioxide, with the formation of oxide and sulphate of lead. The heat is then raised in the absence of air, when the two elements, oxygen and sulphur, unite into sulphur-dioxide, and the molten lead remains. Lead ores are smelted in the reverberatory furnace, the ore hearth furnace, and the blast-furnace. The use of the first two is restricted, as they are suited only for galena ores or mixtures of galena and carbonate, which contain not less than 58 per cent. of lead and not more than 4 per cent. of silica; further, ores to be treated in the ore-hearths should run low in, or be free from silver, as the loss in the fumes is excessive. All lead ores, however, are successfully smelted in the blast-furnace. Blast-furnace treatment has therefore become most popular.

A modern blast-furnace used in the reduction of lead, is oblong in plan view and about 24 feet high from furnace floor to feed floor. The furnace proper, resting upon arches supported by four cast-iron columns about nine feet high, is usually of brick, red brick on the outside, fire-brick on the inside; sometimes it is surrounded by wrought iron water jackets. There is an inclined channel running through the sidewall, beginning near the bottom of the crucible and ending at the top of the hearth, where it is enlarged into a basin. The crucible and the channel form the two limbs of an inverted siphon. While the furnace is running, the crucible and channel remain filled with lead; all the lead reduced to the metallic state in smelting collects in the crucible, and rising in the channel, overflows into the basin, whence it is removed. The slag and other impurities, or *matte* formed floats upon the lead in the crucible and is allowed to flow off through tap holes at intervals into slag-pots, where the heavy matter settles to the bottom and the light slag remains on the top. When cold they are readily separated by a blow from a hammer.

A furnace, 42x120 in., with a working height of 17 to 20 feet, will put through in twenty-four hours, with twelve men, 12 per cent. coke and a two-pound blast-pressure, 85 to 100 tons average charge, *i. e.*, one that is medium coarse, contains 12 to 15 per cent. lead, not over 5 per cent. zinc, and makes under 5 per cent. matte. The cost of smelting a ton of ore in Colorado in a single furnace, 42x120 inches, is about $3.00.

Some of the more important industrial uses of lead are: (1) Lead pipes—drainage pipes in plumbing. (2) Lead oxide—in paints. (3) Plates for storage batteries. (4) In the manufacture of glass. (5) Cable covering. (6) Solder—compounded with tin. (7) In the manufacture of pencils. (8) Weightings for machine parts and other purposes. (9) In the manufacture of ammunition.

Lead is used in the manufacture of pipes that are to be used for drainage purposes in plumbing systems because it is not easily affected by the various acids or chemical reagents which are likely to find their way into such pipes. It is likely to prove dangerous, however, if used in the drinking water supply pipes because of the oxide which is formed when it remains in contact with water for any length of time. This oxide (PbO) is poisonous.

Various lead oxides are used in the manufacture of paints, the most important and perhaps the best known of which is *white lead*. White lead is sold ground in oil, reduced to a thick paste, and is used in oil painting as a body for the formation of tints of any color. Another of the oxides of lead that is much used in connection with painting is red lead. It is used chiefly as the ground for paints for iron and steel work, its function being to prevent the oxidation, called rusting, which always takes place when these metals are exposed to the action of atmospheric moisture. Chrome yellow is another compound of lead that is used a great deal in painting.

The plates of an electric storage battery are made of lead and this has given rise to the habit in the electrical world of calling these batteries *lead accumulators*.

Lead is also used in the manufacture of glass, it being mixed in varying quantities with the silicon and other ingredients which are melted together and blown into the glass forms. This should not be confused with the so-called *leaded glass*, which consists simply of glass with lead strips laid between the pieces for decorative purposes.

Lead is often employed as a covering or sheath for cables to be used in electrical work. It has two characteristics which make it especially suited for this purpose. First, it resists the action of the weather better than other practical coverings; second, it has an electrical advantage of being non-inductive, which results in its preventing a loss of current and also of interference from outside currents in the cable which it covers.

Lead, combined with graphite, is used in the manufacture of pencils; the cheaper pencils contain more lead than graphite. This is not desirable from the standpoint of the quality of the pencil, but it is cheaper.

Solder, used by the tinsmith, is a compound of lead and tin, the proportions of the constituents varying with the use to which it is

to be put. For ordinary work, for instance in the soldering of tin utensils, the proportion is usually half and half.

Another, and at present a quite significant use of lead is in the manufacture of light ammunition, *i. e.*, bullets, and shot for paper cartridges.

COPPER

Copper and its alloys are the first metals of which we find any mention made in history, and there are numerous objects made of copper or its alloys in existence today that the leading archeologists claim date back to 3,000 years before the time of Christ. But of the modern important producing fields only those of Spain, Germany and Japan have a history that began earlier than 1835.

The first copper discovered in the United States was found in Massachusetts in the year 1632. In 1709 a company was organized in Granby, Connecticut, for the purpose of working the Simsbury copper mine, but only a small amount of copper was taken from this mine. Work was started on the copper deposits of New Jersey in 1719. The mines in Vermont, opened in the eighteenth century, were the principal source of American production, however, until the opening of those in the Lake Superior region in 1884.

Jesuit missionaries discovered the Lake Superior mines in the latter part of the sixteenth century. An English company was formed and the mines on the Ontanagon river were first worked in 1771, but the men were killed in an accident and the mine was finally abandoned. Copper mining was begun in Tennessee in 1850, neglected during the Civil War, and resumed in 1890.

Serious copper mining in the United States dates from 1884 with the production of a few tons of black copper ore, probably Chalcocite, taken from a mine at Copper Harbor, Michigan. The beginning of the Lake Superior copper industry was crude, but the growth was steady from the start, and within twenty years these mines became the most important producers in the country, and second only to the mines of Chili. The existence of the rich copper fields of the Lake Superior district was known to the American Indians, and it is certain that the mines had been worked by a former prehistoric race.

Montana is now the largest copper producing district in the world. The first copper was procured there in 1882. Copper was found in Arizona in 1872.

The United States produces more copper at the present time than any other country. The total amount produced in the United States during the year 1911 was 1,090,000,000 pounds. This was about 65 per cent. of the total amount produced in the entire world during that year.

There are nearly two hundred distinct copper ores, but the principal ones of commercial value may be divided into seven classes as follows: (1) native copper; (2) oxide ores; (3) carbonic ores; (4) sulphide ores; (5) sulphate of copper; (6) the arsenides; (7) the chlorides. In commercial importance the sulphide group is easily in the lead, about three-quarters of the world's supply coming from this class. Of this group Chalcocite alone produces nearly one-half of the world's supply of copper. Next in importance commercially is native copper, which is mined extensively in the Lake Superior district. Third in importance are the carbonates, Azurite and Malachite being the only ones found in large quantities. Malachite is most important, as it is rich in copper and is easily smelted.

There are three general methods of extracting copper from its ores. The dry, the wet, and electrolytic methods. The wet method is used the least of the three, and consists in placing the ores in an acid solution which dissolves the copper, which is then precipitated to the bottom of the tank by the addition of suitable precipitants. The dry method is the one generally used for reducing the ore, especially when it is rich in copper. The method consists of two operations: first, roasting the ores; second, smelting the roasted ore in a blast furnace.

The ore is first *heap roasted* out of doors, the fuel being wood. One cord of wood is all that is necessary to roast forty tons of ore. The wood is placed so as to form chimneys through the ore pile. The burning wood releases and sets fire to the sulphur of the ore which burns again and releases more sulphur. The roasting pile will burn for several weeks.

In copper smelting, blast furnaces and reverberatory furnaces are used. The smelting of copper ore in a blast furnace is the process of reducing the copper from its ores by subjecting the ores to an intense heat in a cupola. Coke is the fuel used, and the heat is obtained by turning into the cupola a blast of air heated to about 800 degrees Fahrenheit. The largest blast furnace in this country is that at the Washoe Works of the Anaconda mine in Montana. It is 80 feet long, and has a capacity of 2,700 tons of ore a day.

The reverberatory furnace is one in which the heat from the fuel is reflected back again to the ore, giving a steady but less intense heat. The reverberatory furnace is used in the reduction of the sulphide ores in preference to the blast furnace, as the sulphur contained in the ore assists in its reduction. The largest reverberatory furnace is at the Anaconda mine in Montana. It is 119 feet long, and has a daily capacity of 300 tons of ore.

The Bessemer converter is a type of blast furnace that is also used in the smelting of copper ores. These converters are cylindrical shells, made of boiler plate steel, about four feet in diameter and ten feet high. The shells are mounted on a trunnion, with a tilting device

for emptying the charge. Air is blown through the melting ore at a pressure of fourteen pounds to the square inch. The condition of the ore is judged by the color of the flames issuing from the top of the converter. Fifteen tons of ore can be converted to a metallic state in about one hour. The resulting copper is known as "blister copper" and is used for the "anodes" in the electrolytic process.

When especially pure copper is desired, or when the ore is known to contain a considerable percentage of gold and silver (which is often the case), the electrolytic method is used. This method consists of attaching a thick plate of "blister" copper (called the "anode"), weighing about 200 pounds, to the positive pole of a dynamo, and a thin sheet of copper, called the "cathode," to the negative pole. These plates are immersed in an acid solution, and an electric current is passed from the anode through the solution to the cathode. This results in dissolving the anode, which is deposited upon the cathode, the gold and silver falling to the bottom of the solution. The copper deposited upon the cathode is pure copper and the precious metals at the bottom of the solution are recovered by the use of precipitants and mercury. The metals that are precipitated to the bottom of the solution usually consist of about 40 per cent. silver, 25 per cent. copper, 2 per cent. gold, 10 per cent. arsenic, the balance consisting of lead and other impurities. The acid solution used in this process consists of: sulphuric acid, 10 per cent.; bluestone, 15 per cent.; water, 75 per cent.; and a very small percentage of sodium chloride, for the purpose of precipitating the silver. The solution is contained in large wooden tanks lined inside with lead and painted with tar. Electrolytic refining costs about $12.00 per ton, and the bulk of the world's copper is treated by this method. The copper thus produced averages 99.93 per cent. pure; it is also the best conductor of electricity, which is an important consideration since this is the greatest use for copper at present.

Copper is very malleable and ductile and may be drawn into fine wire or rolled into thin foil one two-hundredth of an inch thick. It becomes harder as it is worked, but by heating to about 608 degrees Fahrenheit it regains its malleability. It may be thrown into water while red hot and cooled quickly or it may be allowed to cool in the air; it will be equally soft in either case. This process of softening by heating and cooling is known as *annealing*.

There are two methods of rolling copper into sheets, the straight rolling system and the "Welsh" cross rolling system. The straight rolling system consists in rolling a plate of copper between hardened steel rolls to about 0.25 or 0.75 inch thick, cutting it to the proper weight for the desired *gage* or thickness of the sheet, then heating and rolling in packs, on finishing rolls, to the desired length. The Welsh cross rolling system is much slower and more expensive and is being

superseded by the straight rolling. Cross rolling is done by rolling cake copper to sheets about 25 inches wide and about one-quarter inch thick, cutting to the desired weight and rolling cross-wise to the desired width.

Copper is also placed on the market in the form of *wire bars* about three and a half inches square and five feet long, averaging in weight about 350 pounds. These are used for drawing down into wire of various shapes and sizes.

Another form in which copper goes to the market is the *ingot* of about sixty pounds by weight, with two deep depressions so that they can be readily cut into three parts for convenient handling in melting and casting.

Some of the industrial uses of copper are:

(1) Wire for electrical work.
(2) Copper tubing.
(3) Copper roofing.
(4) Copper utensils.
(5) In manufacture of brass
(6) In manufacture of bronze.
(7) Paint coloring (copper oxides)

Perhaps the greatest use of copper is in the manufacture of wire for electrical work. Because of its high conductive quality copper is especially well suited for electrical transmission and in this electrical age the amount which is thus used is enormous. In 1911 in the United States alone about 731,000,000 pounds, or about fifty per cent. of the total amount cast, was cast in the form of wire bars. These bars are about five feet long and three and one-half inches square in cross section and weigh about 350 pounds each. They are sent through a number of rollers, each set reducing the cross section of the bar and increasing its length until approximately the diameter desired is reached. The bar, or wire as it may now be called, is then drawn through a steel plate which has many accurately drilled holes, the holes being graduated in size from large to small. The wire is first drawn through the larger hole, and finally through a hole whose diameter is exactly that desired for the wire.

The use of copper for the manufacture of tubing has come to be quite extensive, due chiefly to the increased use of copper tubing in finer engineering work, and in the laboratory. Copper tubing in various kinds of heating coils, in steam gauges, in forced feed oiling systems, etc., will increase in use with the growing use of these appliances.

The use of copper for roofing is significant, though, owing to the expensiveness of this form of roofing, it is nothing like so extensive as the use of sheet iron (incorrectly called tin) for roofing. Copper has an advantage over tin in its ability to resist the corrosive effects of atmosphere and moisture, a copper roof needing no attention in the way of painting, as does a so-called tin roof.

Another important use of copper is in the manufacture of the

alloys, brass and bronze. Brass is an alloy of copper and zinc and contains anywhere from 60 to 85 per cent. of copper. This large percentage of copper in an alloy which is used so extensively as is brass necessarily takes a large part of the annual supply of copper. This usage is perhaps next to copper wire in the amount of copper consumed. Bronze is an alloy of copper, tin and zinc, and sometimes lead. Monument bronze, for instance, contains 87 per cent. copper, 7 per cent. tin, 3 per cent. zinc, and 3 per cent. lead. Bells are made of copper 75 per cent. and tin 25 per cent. Phosphor bronze, used extensively in boat building, is composed of copper 80 per cent., tin 15 per cent. and zinc 5 per cent. When it is being melted a flux of phosphorus is used, hence the name phosphor bronze.

As a coloring material for paints copper is found in a number of forms, the most important of which are verdigris, emerald green, and Scheele's green. Verdigris is an acetate of copper, of a bright green color, inclining to blue. Emerald green is made by mixing verdigris with a solution of arsenious acid. It is a brilliant color, but very dangerous owing to its poisonous effects. Scheele's green is a compound oxide of copper and arsenic. It is of a beautiful, light, warm, green color, opaque, permanent in itself and in tint.

TIN

Tin is a metallic chemical element, which as a component of bronze, was used as a metal thousands of years prior to the dawn of history. Grains of metallic tin occur intermingled with the gold ores of Siberia, Guiana and Bolivia, and in a few other localities. Of the minerals containing this element the most important are tinstone and tin pyrites. Of these tinstone is of the greatest commercial importance. It is found imbedded in rock masses either in or closely associated with the fissure veins. It is also found in the form of rolled lumps or grains, "stream tin," in beds of gravel or sand which have been formed by rivers. These are secondary deposits, the products of the disintegration of the first-named primary deposits. Over five-sixths of the world's total production is derived from secondary deposits, but all the tin now mined in Cornwall and Bolivia is from vein mining, while a small portion of that yielded by Australasia comes from veins and from rocks carrying disseminated tinstone.

The operations in the metallurgy of tin may be enumerated as follows: (1) mining and dressing; (2) smelting; (3) refining. The first stage has for its purpose the production of a fairly pure tinstone; the second the conversion of the tinstone (or oxide) into metallic tin; the third preparing a tin pure enough for commercial purposes.

The alluvial deposits (secondary deposits) are almost invariably worked opencast. In a few instances hydraulic mining has been resorted

to, and in other cases true underground mining is carried on; but the latter is both exceptional and difficult. The alluvial ore is washed in various simple sluicing devices by which the lighter clay, sand and stones are removed and the tinstone left behind comparatively pure and containing usually 65 to 75 per cent. of metallic tin.

Lode tin, as tin derived from the primary deposits is often termed, is mined in the ordinary method. The vein-stuff is broken small either by hand or in rock-breakers, and stamped to fine powder in stamp mills, which are practically large mechanically-worked pestles and mortars, the stamp proper weighing from 500 to 1,000 pounds. The mineral, crushed small enough to pass through a sieve with perforations one-twentieth of an inch on a side, leaves the stamp mill in suspension in flowing water, and is thus carried through a series of troughs in which the heavier mineral is collected; this then passes through a series of washing operations, which leave a mixture consisting chiefly of tinstone and arsenical pyrites, which is roasted and then washed again, until finally block tin containing about 60 to 65 per cent. of metal is left. The calcination, or roasting, is preferably effected in mechanical roasters, it being especially necessary to agitate the ore continually, otherwise it cakes.

The dressed ore is smelted with carbon by one of two main methods, viz., in the shaft furnace and in the reverberatory furnace. The former is better suited to stream tin, the latter to lode tin, but either ore can be smelted either way, although reverberatory practice yields a purer metal. Shaft furnace (blast-furnace) smelting is confined to those parts of the world where charcoal can still be obtained in large quantities at moderate prices. The furnace consists of a shaft, circular (or more rarely rectangular) in plan, into which alternate layers of fuel and ore are charged and an air blast introduced near the bottom of the furnace through one or more tuyeres. This was the primitive process all over the world; in the East, South America, and similar regions it still holds its own. In Europe and in Australasia it has been practically replaced by the reverberatory furnace process. In this process the purified ore is mixed with about one-fifth of its weight of a non-caking coal or anthracite "smalls," the mixture being moistened to prevent it from being blown off by the draft, and is then fused in a reverberatory furnace. The slag and metal produced are then run off and the latter is cast into bars.

All tin, except a small quantity produced by the shaft furnace process from exceptionally pure stream tin ore, requires refining by liquidation and "boiling" before it is ready for the market. In the English process the bars are heated cautiously on an inclined hearth, when relatively pure tin runs off, while a skeleton of impure metal remains. The metal run off is further purified by *poling, i, e.*, by stirring it with the branch of a tree—the apple tree being preferred

traditionally. This operation is intended to remove the oxygen diffused through the metal as oxide; part of it perhaps, chemically by reduction of the oxide to metal; the rest of it by conveying the finely diffused oxide to the surface and causing it to unite there with the oxide scum. After this the metal is allowed to rest a while in the pot at a temperature above its freezing point and is then ladled out into ingot forms, care being taken at each stage to skim off the top stratum. The original top stratum is the purest, and each succeeding lower stratum has a greater proportion of impurities; the lowest consists largely of a solid or semi-solid alloy of tin and iron.

Commercially pure tin is used for making such apparatus as evaporating basins, infusion pots, stills, etc. It is also employed for making two varieties of tin-foil, one for the silvering of mirrors, the other for wrapping up chocolate, toilet soap, etc. For making tin-foil the metal is rolled into thin sheets, pieces of which are beaten out with a wooden mallet. As pure tin does not tarnish in the air and is proof against acid liquids, such as vinegar, lime juice, etc., it is utilized for culinary and domestic utensils. But it is expensive and tin vessels have to be made very heavy to give them stability of form; hence it is generally employed merely as a protective coating for utensils made essentially of copper or iron. The tinning of a copper basin is an easy operation. The basin, made scrupulously clean, is heated beyond the fusing point of the tin. Molten tin is then poured in, a little powdered sal-ammoniac added, and the tin spread over the inside with a bunch of tow. The sal-ammoniac removes the last unavoidable film of oxide, leaving a purely metallic surface, to which the tin adheres firmly. For tinning small objects of copper or brass, such as pins, hooks, etc., a wet-way process is followed. One part of cream of tartar, two of alum and two of common salt are dissolved in boiling water, and the solution is boiled with granulated metallic tin to produce a tin solution; and into this the articles are put at a boiling heat. In the absence of metallic tin there is no visible change; but as soon as the metal is introduced, an electrolytic action sets in and the articles become coated over with a firmly adhering film of tin. Tinning wrought iron is effected by immersion. The most important form of the operation is the making of tinned sheet iron from ordinary sheet iron. The plates having been carefully cleaned with sand and hydrochloric or sulphuric acid, and then with water, are plunged into heated tallow to drive away the water without oxidation of the metal. They are next steeped in a bath, first of molten ferruginous tin (*i. e.*, tin impregnated with iron), then of pure tin. They are then taken out and kept suspended in hot tallow to enable the surplus tin to run off. The greater part of the tin produced metallurgically is used for making alloys, such as pewter and bronze.

The industrial uses of tin may be grouped as follows:

(1) In sheet metal form for roofing, cornices, etc.
(2) Spouting and pipes.
(3) Utensils.
(4) Solder
(5) Bronze
(6) Tin foil.

So called tin in sheet metal form is really sheet iron plated with a thin coating of tin. Tin resists corrosion better than does iron, hence in all places where the sheet iron is to be exposed to the action of the atmosphere and moisture it is coated with tin. For roofing, cornices, and such work, the ease with which tin can be handled, and its durability have made it popular.

Sheet tin, or sheet iron plated with tin and rolled into pipe form and soldered at the seams, is commonly used for rainspouting and for other purposes where the internal pressure is not very great. The use of tin piping in flour mills for the conveyance of the partly ground flour from one machine to another is an example of this latter use.

One of the commonest uses of tin, however, is in the manufacture of utensils of all sorts—tin cans, tea-kettles, cups, boxes, etc. The tin used here is usually of a better grade than that used for roofing, the tin coating on the sheet iron being thicker.

The use of tin in the manufacture of solder has already been mentioned, as has also its use in the manufacture of bronze.

The practice, recently developed, of wrapping candies and various other food stuffs, and tobacco, in tin foil is now quite extensive and consumes quite a bit of the annual production of tin. Tin foil is also used to some extent in electrical work.

CHAPTER III.

WOOD MANUFACTURE

THE LOGGING INDUSTRY*

MOST of the people in the world today are dependent upon lumber or other wood products for shelter and many necessary commodities. This may be thoughtlessly questioned with regard to the man who has built a concrete house. But even here we must think of the wooden forms used in pouring the walls, the furring and shingles on the roof, and the interior wood trim. It would be an easy matter to list a hundred articles that we all use every day, some part of which is made from wood or its products. Realizing the importance of wood in our daily lives, let us investigate its transformation from tree to finished product. The first stage of this transformation is lumbering.

When lumbering is engaged in upon a large scale, a small group of men are first sent into the forest on a land-looking trip. They inspect the various parts of the forest, looking for the best timber and determining the most economical way of transporting it to market. A suitable site for operations is chosen and the location of the main camp is decided upon. To definitely mark off the timber tract it is customary to bound it by *blazing* or gashing trees which then serve as markers. The foreman of the company operating on the land hires all the men needed to do the work. The list includes lumberjacks, cooks, clerks and a blacksmith. A complete outfit is gotten together which includes teams, wagons, saws, and other lumbering tools, stoves and cooking utensils, a blacksmith outfit and a stock of supplies sufficient to last several months. These goods are hauled in over a rough *tote road* cut through the forest to the main camp site. The men are now set to work building the bunk-house, office, blacksmith shop, mess house and the stables. Not until these buildings are finished and everything is in place does the real work of lumbering begin.

The first great task in the lumbering operations is the building of a wide, smooth road which extends from the heart of the forest to a place from whence the logs can be transported readily, either by rail or by water. The road must be carefully built in order that it may withstand the weight of loads of logs weighing many tons. Every stump and rock is removed; the roadbed is plowed and packed, strong bridges built, and everything put in first-class condition. Wherever needed, *skidways* are built at the side of the main road. These are

* For a more detailed description of the logging industry, see Handwork in Wood, by William Noyes. This article is a brief résumé of Professor Noyes chapter dealing with the subject of Logging.

merely cleared areas upon which logs may be temporarily stacked before hauling. From the skidway narrow *dray roads* must be chopped back through the forest so that the logs may be dragged by teams to the skidways.

The second part of the lumbering consists in cutting the trees and trimming the logs. Preliminary to the cutting, however, a *fitter* goes over the woods and designates each tree to be felled by means of an ax gash on the side toward which it is to fall. The *sawyers* now enter the woods in pairs to fell the trees. When they begin to fell a tree they first chop a deep notch into it on the side toward which it is to fall. Then with a thin, flexible crosscut saw they begin to cut the tree off, starting on the side opposite the gash. When partly sawn the tree will settle down, closing the kerf, or opening made by the saw, and pinching the saw. This is remedied by driving into the kerf an iron wedge, using a large wooden maul. The sawing and wedging are continued until the tree is nearly sawn off. If it does not now fall of its own accord more wedges are driven in, until the tree is finally thrown in the proper direction. A great amount of judgment and skill must be exercised in felling a tree to avoid serious accidents and to keep the tree from lodging in the branches of others nearby. Very heavy trees must not be allowed to fall across stumps or hard ground lest their trunks be split from the impact. Sometimes brush is piled upon the ground to make a falling bed for a large, valuable tree. In hilly countries trees are thrown uphill to shorten the falling distance.

When a tree has fallen the sawyers pass on to others while the *swampers* trim off the branches close to the trunk and cut the tree into standard length logs, exercising great care to avoid knots and irregular or rotten parts.

The third stage of the work consists of dragging the logs to the skidways where they are piled. Generally a man does the skidding with a team, hitching to the logs by chains or with tong-like hooks, and snaking them to the skidway. Here the logs are placed crosswise on two skids or small logs laid about ten feet apart and at right angles to the main road. Since many logs must be placed on one another they are *decked* on the pile by means of a horse hitched to a log chain which is fastened to the pile of logs, and extends out under the log which is being decked and back over the top of all, to the horse on the other side. These logs lie on the skidways, while others are being cut and piled, until winter sets in and enough snow comes to prepare for the sleigh haul.

When the logs are all on the skidways two *scalers* work at the log piles, one at each end, measuring the logs to determine the number of board feet of lumber in them and marking them with the company's name by means of an iron stamp made with a handle and used like a hammer.

As soon as the cutting, skidding and scaling of the logs is finished the men turn their attention to preparing for their hauling to the shipping point. They again go over the main road and fix any irregularities in its surface. Then with immense road sprinklers the surface is flooded with water in freezing weather. By repeated sprinkling the road becomes a hard and smooth bed of ice.

Heavy sleds are now drawn to the skidways and are carefully loaded with immense piles of logs. The method of loading is the same as that employed in decking on the skidways. When the sled is loaded and the logs securely chained and clamped in place a single team of horses is hitched on to pull it to the shipping point. The horses must have very sharp shoes to pull on the icy road, but on account of the smoothness and slope of the road they do not have to pull very much, but rather to guide and check the rush of the load, especially on the steep places. The drivers of these immense loads must be skilled horsemen, for if the load gets away, or leaves the road, undoubtedly the driver as well as the team will be killed. When the load reaches the shipping point it is stopped opposite two skids which with others reach to the railway cars, or to the river, as the case may be. The load is now unchained and the logs allowed to roll off the sled and upon the skidways. They are now, by means of a horse and chain, either loaded directly on cars and shipped, or else rolled out upon the ice which at this time covers the river. The hauling continues until every log has been decked on the ice in the river. Then all that can be done is to wait for the spring thaw to release them.

When the ice begins to thaw and the freshets to fill the river, the lumberjacks don their waterproof clothing and heavily spiked shoes. Then with their *peaveys*, a sort of cant hook and pike pole combined, which they use to roll and propel the logs, they set to work. When the ice and logs start to move some of the men have to ride them to help prevent jams, while others work along the shore to keep the logs from landing and also to start those which have become lodged along the shore. The men must be skillful in handling the logs to keep them moving; sometimes in spite of their efforts, the whole group becomes wedged and forms a jam. On account of the great pressure of the water and of the logs behind, it is almost impossible to start the mass moving without the aid of dynamite blasts to break the key logs or those which are doing the holding. Log jams have been successfully broken by damming the stream above the jam so that when the dam is removed the large volume of water will sweep the logs upward and forward. Thus the drive continues until the logs reach the mill where they are to be taken care of. Here a heavy fence of logs is stretched across the stream to stop them and to guide them to the mill pond where they are allowed to float until they are finally sawn up into lumber.

CHAPTER IV.

CHEMICAL PRODUCTS

THE SOAP INDUSTRY

CLEANLINESS may be said to be the indication of a higher type of civilization. There has been, upon the part of man as he has advanced in civilization, an increasing demand for sanitation and cleanliness. It is because of this demand that there has been brought into being the industry of soap making.

It is quite likely that the first substance used for cleansing purposes was the juice of certain kinds of plants. The ancients also used fuller's earth, a soft substance, resembling clay but which is not plastic, a material which later came to be used extensively in fulling woolen cloth, *i. e.*, cleansing and shrinking it. This earth was spread over the surface to be cleansed and was stamped in by the feet. Then by subsequent scouring the greasy matter and dirt were removed, the fuller's earth having the property of absorbing both grease and dirt.

According to the Roman historian, Pliny, the Gauls were the original inventors of soap, their best product being a combination of goat's fat and the ashes of beech wood. The Romans, after their invasion of Gaul, introduced the art into Italy. In proof of the antiquity of soap making, a soap maker's shop was discovered in the ruins of Pompeii, the Italian city which was buried beneath the ashes of Mt. Vesuvius, in 79 A. D. This ruined shop is still exhibited to tourists.

In the eighth century soap was manufactured to quite a large extent in Italy, Spain and Germany. The industry was carried on partly as a household art and partly as a trade. Strange to say, it was not introduced into France until the thirteenth century, and yet in France are to be found the conditions which are most favorable to the production of the raw materials necessary. The exact period in which soap was first manufactured in England is uncertain. It was probably sometime during the fourteenth century. Soap was here made according to the French method, *i. e.*, with borilla or crude carbonate of soda.

The art of soap making has passed thru a long period of rude and unscientific manipulation; at present, however, it is commanding the attention of scientific men. The first invention of importance, which led to its perfection was that of Leblanc, a Frenchman, who discovered a way of obtaining soda from common salt. Rapid advance in chemical knowledge has been a means of greatly improving the art of soap making in that many saponifiable substances, such as oils (olive, cocoanut, fish, palm, castor, etc.) and other fatty substances (lard, tallow,

etc.) have been introduced. The prejudice against men of scientific ability entering the soap making industry, was at first so great that until about sixty years ago soap makers seldom, if ever, consulted scientific men.

In making soap today, a large kettle is provided, in which the contents can be boiled either by direct heating or by free steam. A kettle that will hold 100,000 pounds of soap is 15 feet in diameter and 21 feet high. Such kettles are usually made of $\frac{3}{8}$-inch iron boiler plate. Melted fat and lye are run into the kettle and boiled until saponification begins to take place. The soap material feels dry and firm as it is tested between the fingers. The mixture is now salted with common salt. This operation causes the soap to separate from the caustic lye and glycerine. The adding of salt also causes the soap to rise to the top and to solidify. If soft soap is wanted, no salt need be added. The liquid is left standing in the kettle until all of the soap in it rises to the surface, the lye being drawn off at the bottom of the kettle.

More strong lye is added and boiling is continued, this time until the material has fully saponified. The experienced soap boiler knows by sight and touch just when complete saponification has been accomplished. The material is again allowed to stand and the additional lye is drawn off. It is then boiled with water and afterwards allowed to settle a second time. In the process of settling, the remaining superfluous alkali, dirt and impurities are separated.

After standing for several days the material is finally pumped into the *crutcher* which consists of a broad vertical screw working in a cylinder placed in a large tank. Here it is thoroughly mixed, and perfume, or scouring materials, are added if desired. It is drawn off into large rectangular frames which hold about 1,000 pounds. Here it is allowed to solidify. After solidification has taken place the sides and ends of the frames are removed and the mass is cut out by means of wires, into slabs which are again cut, this time into the commercial bars. The bars of soap are now wrapped, packed into boxes, which usually hold one hundred bars each, and stored in the large store rooms.

Tallow, palm oil and cocoanut oil are used in making white soap. Yellow soaps are made in the same way, except that a considerable amount of rosin is used. Castile soap, if pure, is made from olive oil, sometimes cocoanut and rape seed oil being added. The following list of the common soaps and soap powders made in the United States is suggestive of the variety now in daily use:

(1) Toilet Soap—
- a. Common—
  - Fairy, Jap Rose, Palm-Olive, Castile, Shaving.
- b. Medicated—
  - Cuticura, Resinol.

c. Liquid.
(2) Laundry Soap—
a. White—
P. & G., Naphtha, Flake White, Crystal White, Galvanic, Ivory.
b. Yellow—
Fels Naphtha, Lenox, Star.
(3) Soap Powders—
a. Simple—
Shaving, Gold Dust, Snow Boy, 20-Mule Team Borax.
b. Scouring Powder—
Tooth Powder, Old Dutch Cleanser, Polly Prim, Kitchen Cleanser.
(4) Soft Soap.
(5) Scouring Cakes—
Sapolio, Bon Ami.

CHAPTER V.

PAPER AND PAPER PRODUCTS

PAPER—ITS EVOLUTION

IT is not possible for us to obtain the earliest records of the race. Its activities in the most ancient of times were not recorded as they would be today. When men first realized a need for conveying to later generations a record of their achievements they sought for the best method of accomplishing this purpose.

At first history was repeated from father to son by word of mouth, and thus traditions were handed down from generation to generation.

Later, people began to see that sometimes traditions were forgotten or were retold in a different way. Some method was needed to record events accurately and for all time. To meet this need stone covenants or cairns were set up, great heaps of stone. Later still, obelisks with inscriptions on them were employed.

Events of minor importance were left unrecorded because it was too expensive to set up covenants in their memory. The people of Chaldaea and Assyria overcame this difficulty by inscribing their records on soft clay tablets which were baked in the fire. Some of these clay tablets are still preserved. Sometimes tablets of bone, brass, lead and gold were also inscribed. The forerunner of the modern newspaper was realized at the time when large wooden tablets covered with a thin coat of wax were posted in public places in the towns of the Roman Empire. Each day the news items were scratched on these boards. When men wished to erase these inscriptions they heated the wax and allowed it to set again into a hard, smooth sheet.

But messages had to be sent long distances and since tablets were too heavy to transport, writings were inscribed on the skins of animals. It was afterward discovered that layers of the papyrus reed could be made into a good writing material. This plant grew along the River Nile in Egypt. Layers of papyrus were laid across one another and, after being moistened with sticky water, they were compressed to a thin sheet and polished with a piece of ivory. Since papyrus grew only along the banks of the Nile, the King of Egypt at that time had entire control of the supply of the world's best writing material.

When the King of Pergamos in Asia wished to create a great library, the King of Egypt grew jealous and refused to furnish the papyrus for his writing material. The King of Pergamos then discovered a method of making parchment from the skins of sheep, goats and calves. Then his library grew faster than ever. The skins were first steeped in lime pits, and were then stretched tight upon frames.

The hair and refuse were removed and the skins were scraped to an even thickness by means of sharp knives. They were then sprinkled with chalk and polished with pumice stone. Thus, a very fine writing material was produced. Although parchment proved to be an excellent writing material, it was entirely too expensive for any but the richer classes. A cheaper material was needed.

As early as 600 A. D. the Chinese had made a fibrous material for writing, resembling our modern paper. About 751 A. D. the Arabians learned the secret and made paper from various vegetable fibres. Later the Crusaders introduced paper making into Europe, where it flourished, especially in Holland. Finally the art was brought to America by a Hollander who established the first American paper mill at Germantown, Pennsylvania.

The raw materials used in paper making today are linen and cotton rags, wood, esparto grass, straw, flax, hemp, jute, bamboo, silk, sugar cane refuse, etc. These materials are sorted, boiled, washed, ground to pulp, bleached and pressed. The pulp is colored if desired, and the paper may be sized and coated or glazed.

Paper is of three general kinds, namely, writing, printing and wrapping. Among the special kinds the following may be mentioned: vulcanized, corrugated, carpet, waxed, crepe, sand, emery, litmus, blue-print, papier-mache, asbestos, tar, cardboard, stencil, transparent, tissue and filter.

Paper has not only filled the demand for a cheap, serviceable writing material on which can be recorded the history of the race, but it renders service in many other ways. Car wheels have even been made of it.

PAPER MAKING

It is little short of marvelous to see dirty and unsightly rags turned into snow-white sheets of writing paper, and yet it is a fact that the manufacturer of paper is dependent upon the rag picker for most of his raw material.

Rags are gathered and sent in bales to the paper mill where they are opened and fed into a machine called a *thrasher* which beats them and removes most of the dust and dirt. This is carried off by means of tubes, which prevent its floating about the mill and being breathed by the workers. The rags are then sorted and all buttons, hooks, eyes and other hard substances removed.

The large rags are now cut into smaller pieces by hand and are put through a cutting machine which chops them into still smaller pieces. These are fed into another machine called a *whipper*. This machine consists of two cylinders, one operating inside the other. Spikes project from the outside of the inner cylinder and from the

inside of the outer one and the two cylinders are operated in opposite directions at a high rate of speed. As the rags pass between the spikes they are literally torn into shreds, while tubes similar to those already mentioned, again carry off the dust.

But the real process of cleaning begins when the huge lids of the *digester* are opened to receive the torn rags into their solution of lime and caustic soda. The whole mass is now cooked by means of live steam for about twelve hours. When the pulp has at last been removed from the digester the lime and soda solution, which contains a great deal of dirt, is allowed to drain off.

The pulp is now put into *washers* similar to the washers used in laundries, and the remaining dirt and soda solution is washed out. It is then rinsed in clean water containing bleaching materials, and it comes from the washers bleached white.

The shreds are now allowed to drain slowly, sometimes several weeks being allowed for the process. Then the material is again subjected to beaters which further break and tear it and separate the fibres. Adulterations such as coarse fibres are sometimes added during this second process of beating. Coloring materials are also worked in if the paper is to be colored, as well as glue for holding the fibers together.

The pulp containing the various materials added during the process of beating, is now placed in mixing boxes containing water and equipped with agitators or paddles similar to those of a churn, which constantly stir the liquid and mix it thoroughly. The water containing the pulp in even suspension is run over tables which are in reality merely shallow boxes, the bottoms of which are covered with felt. Upon the felt bottoms of these tables is deposited the dirt which was too heavy to be blown away in the preceding operations.

The liquid is now forced through a fine iron screen which further refines it and straightens out its fibres. It is then conducted to an endless wire cloth belt which revolves away from it and carries off the pulp which is uniformly deposited upon it. The liquid passes through the belt and the fibres are carried on. Under the belt is a trough into which all the surplus liquid drains and by which it is conducted back into the mixing box.

The pulp is carried on the belt between rolls which ring it as rags are wrung in a wringer. These rolls also impress into the pulp sheet the *water mark* which is generally the trade-mark of the manufacturer.

From these rolls the pulp, which we will now call paper, passes through other felt-covered rolls which absorb the water, and through still other highly polished heated rolls which dry and further compress it and which give to it a smooth finished surface.

If the paper is to be of the finest finish it is conducted through an

almost endless chain of rolls until it has finally acquired the proper toughness and smoothness; if it is to be ruled, it passes under stationary pens which are automatically fed with ink of the required colors.

When paper is manufactured from wood the process is practically the same as that described above, except that grinding machines are substituted for the cutting machines for reducing the material to pulp. The finest grades of paper are made from new rags direct from the cloth mills. Inferior grades of paper are made by combining wood with old rags and papers. Wood pulp is used today only in the manufacture of the cheaper grades of paper, but it will undoubtedly be but a short time before wood will provide as good a grade of paper as rags now do. This is a problem which is being seriously considered by scientific men.

BASKETS, BOXES AND CARTONS

Manufacturers are beginning to realize that there is a need for adequate baskets, boxes and cartons for use in connection with all industries. The manufacturer feels a need for proper receptacles in which to market his products, while the consumer realizes that products reach him in good condition only when properly packed.

Manufacturers are anxious to have their products so packed that freshness for a long time will be assured. For example, the National Biscuit Company packs all of its products for the retail trade in a patented package, "Inner Seal," which excludes all moisture and germ-laden dust. The package is lined with paraffined paper and covered with an ordinary grade of paper upon which the advertisements and statements are printed.

Cartons are made of several different kinds of paper which make them adaptable to their many uses. For instance, those used in the packing of silverware are made from silver tissue, or grass-bleached tissue, since these papers contain no chemicals which would tarnish the silver.

Wooden boxes are being rapidly replaced by corrugated containers. It will probably be a matter of but a few years before wooden boxes will be relics of the past. Straw is used in the raw material employed in the making of corrugated containers, whereas rags and wood pulp are employed in the manufacture of most paper. Corrugated containers are light and strong and they withstand water quite well. The dead air spaces tend to neutralize an excess of heat or cold. The arched construction of the corrugated container provides strength and elasticity with a comparatively small weight, and last, but not least, the cost of them is moderate.

Modern baskets and berry crates are generally made of native woods, preferably basswood. The logs are sawed to the proper lengths

and after being boiled for about five hours and stripped of their bark, they are put on a turning spindle and revolved against a stationary knife which cuts off thin strips of the wood. These strips are also cut to the proper lengths and widths for basket splints by machine. After the splints have been woven and fastened the basket is pressed into the proper shape and dried. In this way serviceable baskets and crates are made at a very low cost. Baskets are often woven from willow twigs and from rattan. Rattan is a vine which is a native of the Orient and is abundant in the Philippine Islands. These vines often grow to be several hundred feet long. In our factories the long canes are placed in a trough of water and soaked. Then each strand in turn is drawn through a series of small knives which strip off the outer bark in ribbons which are sometimes used for cane seats. They are then drawn through a second set of knives which cut out flat strips of reed winding, usually one-quarter of an inch wide. The round reed of commerce is obtained from the center of the rattan. Round reed is graded in sizes by numbers ranging from 00 (very fine) to 9 (heavy). Large reeds are sometimes cut lengthwise into thin slices called flats which are used in weaving rectangular baskets.

CHAPTER VI.

BOOKS AND PRINTED PRODUCTS

BOOKBINDING

THE book in the course of its evolution has passed through a variety of stages while a great number of materials have been involved in its making. The early Babylonian and Assyrian books took the form of clay bricks. Writings were inscribed while the clay was soft and before they were baked in the fire. The Romans used as writing materials, sheets of soft metal and wooden slabs coated over with wax. The Chinese used the bark of the bamboo to write upon until about 600 A. D. when they invented a material resembling our modern rag paper. They kept the secret to themselves, however, until the tenth century, when the Arabs made its discovery and introduced paper making in Europe.

The earliest permanent manuscript writings were inscribed upon scrolls which consisted of long strips of papyrus, or parchment rolled upon sticks. These rolls were first held vertically for reading, but later were read horizontally from end to end. Later, short lines were used, the mass of inscribed material being broken up into small oblong shapes somewhat resembling page divisions. This dividing of the inscribed material into sections suggested the idea of folding the scroll between these divisions. The strip of papyrus or parchment was now folded backward and forward giving it the form of an unbound book. The back edges later came to be tied together and in this way reading was facilitated and the rolling and unrolling of the scroll in reading avoided. This idea was carried still farther by the Japanese and the Chinese who laced the back edges of the pages together, giving them still more the appearance of a book.

The art of bookbinding is of course much older than that of printing. We find that the Babylonians provided cases of clay for their clay tablets; the Romans made bindings of leather. But these cases were far removed from our modern conception of bookbindings. The ivory cases of the double folded wax tablets of the second and third centuries A. D., which in the strictest sense of the word are not bindings at all, should be mentioned in this connection on account of their beautiful, carved decorations. These cases are among our most cherished examples of Byzantine art.

In the early days of Greece and Rome, manuscripts in scroll form were copied by scholars known as scribes. Books were later made and preserved in the monasteries by the monks who were our first real book makers. Some of these monks spent their entire lives in copying manuscripts. Their monasteries extended from Ireland to

Jerusalem. Thomas Bailey Aldrich has written a poem about the monastic scribe, "Friar Jerome's Beautiful Book." It gives one a clearer understanding of the bookmaker of the middle ages.

Books at this time were for the most part gospels and Psalters, beautifully decorated in brilliant colors. St. Boniface, who lived at this time, wrote a letter to a friend in which he expressed the wish that his illuminated inscriptions might be gay and bright, even as a glittering lamp.

Dagaeus was an Irish monk who was skilled both in bookbinding and illuminating and in the working of metals. He made many beautiful designs for the covers and clasps of books. Ethelsold, of Lindisfrane, made book covers from metal which were brilliantly gilded and jeweled. These early books were generally bound in oak boards and were covered with leather and metal. They were often provided with clasps, corners and other trimmings, which served both as useful and as decorative elements.

The covers of a Psalter, inscribed for a certain countess of Jerusalem, had wooden covers which were decorated with carvings in ivory after the Byzantine style. Bookbinders became more and more extravagant in their materials. In 1583, Henry III of France was forced to decree that civilians must not use more than four diamonds in decorating a single book. The nobility were prohibited from using more than five.

Satchels of leather and book shrines were made extensively by the early bookbinders. The satchels were often decorated with interlaced tooled patterns and with the forms of animals. The monks of Ireland and Scotland were the most extensive users of book shrines.

The early printers were their own binders. Later the binding was handed over to the stationers. William Caxton, the first English printer, bound his books according to the custom of the time, with covers of tooled leather. His decorations were usually made up of diagonal lines. The diamond shapes formed by these lines were filled by a dragon form. In the sixteenth century, books came to be bound in damask, satin and velvet.

The bindings of today are of two types, cloth and leather. The cloth binding is an English invention which came into use about 1832.

There are two stages in the modern process of bookmaking. The first includes the writing of the manuscript and the arrangements between the publisher and author; the second, the overhauling of the manuscript by the printer's reader and the printing of the corrected manuscript. After the sheets of paper, which vary in size according to the size of the book and the number of times each sheet is to be folded, have been printed, they are folded and arranged in piles according to the order in which the sections are to be bound. A folio is a book which is made from sheets of paper which have been folded once,

each sheet forming two leaves or four pages; an octavo, a book made from sheets which have been folded four times, forming eight leaves or sixteen pages, etc. In making up or assembling a book of many sections each sheet in consecutive order is taken from the proper pile, folded into signature form, stitched, glued and placed in the case or covers along with the other sections. Most of this work is now accomplished by means of power machinery.

PRINTING

The value of printing to man can hardly be estimated; the industry can only be appreciated by making a careful study of the slow process of ancient times, and of the evolution which has finally brought about our efficient methods of today.

Just how printing was invented is a fact which has not yet been definitely determined, but it is thought by many who have made a study of the art of printing that intaglio seals used by ancient peoples may have suggested the idea of printing. Intaglio seals were made from stone, often from precious gems. They were engraved, an intaglio being the reverse of a cameo, which is in relief. At any rate, it is but a step from printing upon wax with a seal to printing upon a harder material with an engraved block.

It is likely that the Chinese were the first people to print. We find that engraved wooden blocks were used in China for the printing of books as early as the sixth century A. D. Printing did not spread over the rest of Europe at that time, however. It was reinvented in Western Europe by a German, John Gutenberg, about 1440. Gutenberg's printing shop was quite different from our modern printing establishments.

The first printing which John Gutenberg did was by means of blocks of wood on which he had carved illustrations and letters in relief. The material for a whole page was engraved upon a single block of wood. One day, as the result of an accident, the breaking of one of these plates, Gutenberg discovered that each letter might more advantageously be cut upon a single small block by itself. By this new method, the same letters could be used in many different arrangements. This was of tremendous advantage to the printer in that it saved him much useless labor.

It is interesting at this point to recall the fact that the Chinese had long before also invented the process of printing with movable types, but this method of printing has never been popular in China owing to the almost limitless number of the characters which are employed in the written language of China. China has excelled, however, in her wonderful wood block prints, many of which are still regarded as masterpieces of art.

Gutenberg's discovery soon bore fruit in England, where in 1476 William Caxton had set up a printing press at the Sign of the Pale at Westminster. To Caxton belongs the credit of printing the first book printed in the English language, a translation of "*Recuyell of the Historyes of Troye.*"

Both Gutenberg and Caxton employed a screw hand press which was quite similar to our modern standing press. It consisted of a flat bed upon which the wooden block was pressed by means of a vertical screw which was turned by means of a lever. These presses were at first made entirely of wood. In 1786 M. Pierres, a Frenchman, invented an iron press which was more easily operated.

We find different kinds of presses in use in England, and about 1800 a press was introduced in which a cylinder was substituted in place of the platen or flat bed. This cylinder carried the paper over the type, pressing it down upon the type to receive the inked impression.

The flat bed press was the only press used to any great extent in the United States, however, until about 1850. In 1865, William Bullock, of New York, constructed a cylinder or rotary press which printed from an "endless" roll of paper. In 1847, R. Hoe & Co., of New York, had produced a revolving press in which the type was revolved on the surface of a cylinder. In 1871, the same concern placed upon the market a rotary press which printed both sides of the paper from curved stereotype plates. Our modern city newspaper presses, which turn out upwards of 100,000 copies per hour are similar to the original rotary machine of R. Hoe & Co., although the mechanism has been constantly improved.

The setting of type in regular order for printing is called typesetting or composing. Typesetting is today performed by hand and by machine. In the hand method the type is placed in a shallow drawer which is divided into small compartments into which all letters or figures just alike are placed, the type being so arranged that the letters are most convenient for the compositor, who stands in front of the type case with the copy before him. He holds in one hand a little iron tray called a composing stick and with the other he picks out the type and places it in the composing stick. As fast as the composing stick is filled he places the type which he has thus arranged into a galley which is a long iron slip or tray. In book printing the proof is taken directly from these galleys. The impression taken from the type thus set is called the galley proof. It is corrected again and again and new proofs made until a final proof is returned to the author for his approval. As soon as the proof has passed the final inspection of the author, it is returned to the printer who breaks his galleys up into page divisions.

When this has been accomplished, the type is placed more securely into forms, each form being fastened in place in a strong iron frame which is called a chase.

In modern printing offices, type is for the most part set by means of a *linotype*, a machine that produces words in stereotyped lines. In this machine the type is automatically cast in type metal (antimony and lead) by means of matrices or patterns which form a part of its mechanism.

When only one edition is wanted, as in the case of small job work, the printing is generally done directly from the type, and after printing, the forms are torn down and the type distributed back in the tray. When future editions are likely to be called for, stereotype or electrotype plates are made. In this way the type arrangement can be permanently preserved.

Stereotype plates are made of white metal which is an alloy of tin, lead and antimony. The plates are made by pressing a prepared pulp of wet papier-mache upon the face of the original type. When this pulp has taken the positive impression from the type and has become dry, molten white metal is run upon it to the required thickness. The plate thus formed is fixed upon a wooden block making it the same thickness as the type stems, in order that it may be placed into the forms and chase along with the type. In the case of the plates used upon the cylinders of rotary presses the curved plates are backed by type metal.

In the process of electrotyping the impression is taken by placing a sheet of wax, which has been heated to the proper degree of elasticity, over the face of the original type. When this wax positive impression has been taken, the sheet of wax is placed in a galvanic current where a thin coat of copper is deposited upon its face. This thin sheet of copper conforming to the letter shapes is now detached from the mold and backed with white metal. The electrotype plate now resembles the stereotype plate except that it has the outward appearance of having been made of copper. Stereotyping is quicker and more economical than electrotyping. The latter method, however, is more durable and better suited to high-class printing, which is done on the finest grades of paper.

Printing today is accomplished by steam and electricity, the blank paper being fed in at one end of a machine and turned out a finished printed product at the other, as in the case of magazines and newspapers, at the rate of 100,000 copies per hour. When we stop to compare the early methods of printing with the methods employed today, we marvel at the wonderful advance in this industry which has made knowledge easily accessible to us all, through the printed page.

CHAPTER VII.

TEXTILES AND CLOTHING

CARDING AND SPINNING

WHEN man first began to think of interlacing threads to form a mat, he also thought of using various smaller fibers rudely twisted together, in place of large strands. It at once became evident that a rope of twisted fibers was stronger than a single fiber of equal diameter and so there was really an advantage in using the many small fibers twisted together. Of course the strength of the rope depends also upon the quality of the fibers entering into its construction.

In the most ancient of times, it is likely that the fibers used in making strands, were straightened out or *carded* by hand, with the aid of a board full of spikes, and spun by twisting them together between the thumb and finger, or by rolling them between the palms of the hands. Since it was difficult to handle a mass of straightly carded fibers in the hands without disarranging them, it became the custom to wrap them lightly about a stick, called a *distaff* and to fasten them in place by tying.

The process of spinning fibers with the fingers was very laborious, so people began to use the *spindle*, so called because it spun around when used, as an apple would spin if hung on the end of a long cord.

The spinner would fasten the distaff in her belt or under her arm and, drawing out a few fibers, she would twist them slightly and fasten them in a cleft in the end of the circular, wooden spindle. Then giving the spindle a twirl, she would keep pulling out fibers, while the weight and motion of the suspended spindle would stretch and twist the fibers into a smooth, even thread. Now when the spindle slackened its whirling and stopped, if left alone, it would reverse on account of its weight and untwist the thread. To prevent this, the spinner either gave the spindle an additional twirl in the proper direction, or if the thread was long enough, she wound it around the body of the spindle and again fastened the string in the cleft end, thus going on with the laborious process.

The next radical change in spinning was brought about at the time of the introduction of the so-called *great wheel*. It consisted of a shaft, set horizontally, on one end a little pulley, on the other, a spindle, all belted to a large wheel, which was whirled by hand or by means of a foot treadle. The operator of this great wheel fastened her distaff of carded fibers into her belt and pulling out a few of the fibers, she twisted them and fastened them in the cleft end of the spindle. Then causing the large wheel to revolve with her hand or foot, as the case might be, she fed out fibers and backed away from

the revolving spindle in the direction in which the spindle pointed. When the thread was twisted sufficiently, she stopped the machine. Then in order to keep the spun thread from unwinding, she wound it on the spindle. To do this, she walked around until the thread was at a right angle to the spindle, and slowly turning the wheel, she guided the thread to the center of the whirling spindle and wound it up. Next, she tucked the end of the thread back in the cleft end of the spindle, and feeding more fibers, continued the process of spinning and winding until the spindle was full of spun yarn. Then she wound the yarn off by means of a reeling device into a bundle, called a *skein*.

We can see that the quality of yarn turned out, all depended upon the spinner. If she wished fine hard-twisted yarn she turned the wheel faster and drew harder on the fibers. Sometimes the yarn was not spun firm enough at the first operation and so it was respun as many times as was necessary to give the quality of yarn desired.

For many years people continued using the same primitive methods of producing yarn. About the middle of the eighteenth century, however, reforms of various kinds in the manufacturing world began to be introduced. These completely revolutionized carding and spinning. We recall that at first, carding was accomplished by the hand process of brushing with wire brushes. This method was gradually improved by Paul, Hargreaves, Arkwright and Lees, until by 1774, carding was a strictly modern process accomplished entirely by automatic machines.

Before carding, the fibers must be prepared, as for instance, cotton must be ginned and cleaned, and wool must be scoured and oiled. Then, if necessary, materials from various bales and bundles are thoroughly mixed or blended by being fed at the same time to a rapidly revolving spiked cylinder. The fibers are carded or straightened out by a process somewhat similar to that of combing one's hair. It is accomplished by means of a slowly moving belt and a swiftly revolving cylinder, each covered with a large number of fine, wire teeth, between which the fibers are passed.

Because of the invention of automatic carding machines, which greatly lessened the work of preparing fibers and on account of numerous inventions in the weaving industry, there came to be a great demand for spun yarn to keep the new weaving machines in operation and to take care of the carded fibers being turned out by the automatic carders. It would be necessary for some one to invent a mechanical device for automatically spinning several strands at one time.

In 1738, two partners, John Wyatt and Lewis Paul, invented a spinning device which used drawing rollers to pull out the yarn, and the flyer of the saxony wheel for the twisting of the fibers. About 1765, John Hargreaves, of Lancashire, England, took out a patent for the *spinning jenny*, a machine run by hand and worked intermittently,

like the great wheel. Although it could spin about a dozen threads at a time, they were of a quality which could only be used for the woof or filling threads in weaving.

About three years after this invention, Richard Arkwright, of Preston, England, got out a patent for his *water frame*. It had a continuous motion like the saxony wheel and caused the fibers to be drawn out by two sets of rollers, running at different speeds. The twisting was done by the saxony flyer on an upright spindle frame. The good parts of these two machines were united in 1779 by Samuel Crompton, of Bolton, England, in the *mule spinning frame*. It used the drawing roller, the upright spindle and the movable carriage. This machine proved very capable of making good yarn, which could be used for warp and woof alike.

Finally the triumph of skill in spinning was realized in the invention of the modern self-acting mule, by Roberts, in 1830. When this invention was finally perfected, spinning had again caught up with the production of the carding and weaving industries, and so the output of the three inter-related industries was again balanced.

WEAVING

One of the first industrial arts to be taken up by primitive people was weaving. The Chinese, Hindus, and especially the Egyptians, became very proficient in the art and it was from these that it was introduced into England shortly after the Roman Conquest. The people of the United States learned to weave from the mother country.

Weaving may be defined as the art of interlacing threads of any material into a web. Those threads which extend lengthwise of the woven fabric are called *warp*, while those that fill the fabric, by crossing the warp threads, are called the *woof* or filling threads.

The *loom* is a machine provided for the weaving of various fabrics. In order to accomplish this it must be capable of making three different movements. (1) It must so separate the warp threads that a *shed* is formed, some of the threads being raised while others are being depressed. (2) The woof thread must be passed through the shed formed in the warp. (3) The woof thread must be pushed tightly against the woven fabric. The process of weaving consists merely of carrying on these three operations in the order named.

Formerly most looms were operated by hand, but on account of the rapid advance in the cost of labor, power-looms have displaced them in nearly every case.

When America was discovered the natives were found using a crude sort of loom. The warp threads were wrapped on a stick which served as a roller, while the finished cloth was rolled up on

another stick. The operator either fastened the work vertically in the branches of a tree, or allowed it to lie horizontally on the ground. A long stick was used as a shuttle for the passing of the woof threads. On some of the government reservations Indians may still be seen weaving on looms differing but little from the crude ones of ancient times. But these operators make up in skill what they lose by having such poor tools, and some very beautiful fabrics are thus produced.

All of the arrangements of warp and woof threads are based upon three primary weaves: the *plain*, the *twill*, and the *satin*. The plain weave makes the finest and strongest of all fabrics. In this weave the woof thread passes over one warp thread, under the next and so on across the fabric; when it starts back, it alternates, passing under those threads that it passed over before and over the ones that it passed under before. Only one heddle is needed to form the shed of the warp in this simple weave. By using this form of weaving, we get the greatest possible number of thread crossings per square inch, thus insuring a very strong and durable fabric. When the twill weave is used, the woof thread passes over two warp threads, under two warp threads and so on across the fabric; on its return, it goes over two threads, one that it passed over and one that it passed under, on the previous trip; then it passes under two threads, one that it passed under and one that it passed over, on the previous trip, etc. This sort of fabric, woven with three *heddles*, has a stripe in the weave, which runs diagonally to the right or left. In the satin weave, the woof thread passes under one warp thread, then over four warp threads and so on across the fabric. Upon returning, the woof thread passes under one warp thread, then over four warp threads and continues just as in the previous trip across, excepting that the warp threads passed under are shifted each time two spaces, either to the left or right. Five heddles, or harnesses, are required for the simplest satin weave.

THE LINEN INDUSTRY

Flax, the material from which linen is made, ranks next to cotton among the vegetable fibers of commerce. The great value of this material can be appreciated when we consider that we have articles of linen about us constantly. Our towels are made of linen; we have linen table cloths and napkins spread before us every day; we wear linen dresses and shirts, collars and cuffs, and our handkerchiefs are also made of it. In fact if we were to name all of the articles of clothing and the other uses to which linen is put the list would fill a whole page.

Linen was one of the earliest textiles known to mankind. Cere cloth, its earliest form, woven in Egypt in the time of the Pharaohs, was a much finer cloth than the linen of today. Modern linen looks coarse beside it.

The linen industry was carried on as a household art in England for centuries, the Anglo-Saxons making their clothing largely from this material and from wool. Although it was carried on as a commercial craft in Continental Europe during the twelfth century it was not until the thirteenth century that the industry was protected in England by royal edict. At this time most of this commercial weaving was accomplished by craftsmen imported from Flanders. About eighty years later a colony of Scots began to make linen in the northeast of Ireland. This period was the real beginning of the linen industry in Europe.

Although some flax was grown in America during the eighteenth century, it was not until 1809 that the Legislature of Kentucky petitioned Congress to protect the linen industry in the United States.

Today Russia produces four-fifths of the world's annual supply of the flax fiber. This product, however, is of a coarse quality, hence only coarse linens are made in Russia. The soils of France, Belgium and Holland appear to be peculiarly adapted to the growing of a fine quality of flax. Hence these countries are unequaled in producing fine linens. The linen industry is also of great importance in Ireland, in Italy and in Egypt.

Linen is accorded a respect which we do not give to any other textile, for its long history, its durability and reliability, its exclusive adaptability to many house needs, its purity and wholesomeness. No other fabric is so free from lint, gives up its moisture so readily, is so quickly cleansed, and so pure and hygienic, so tenacious and durable as is linen. Proof that it is durable beyond other materials is shown from the fact that linen taken from mummies buried in the Egyptian tombs 6,500 years ago, has been washed several times without injury to the cloth. Linen has been called the textile of luxury because in the finer grades it is a very expensive material. For the higher grades, such as table damasks, flaxon, and the finer linens, the flax is not grown in the United States but is imported from Europe, the finest grades coming from Belgium.

Unfortunately linen sometimes comes to us in a weakened condition because of the carelessness or rapidity of its preparatory steps, cheap chemicals having been employed in retting, bleaching and dying, and the use of tow or the short fibers instead of the longer ones. It is frequently combined with cotton, but when this is done the properties of linen are lost and the only gain is in cheapness. For this reason it is of advantage to all to be acquainted with some of the tests for linen. The principal tests are: (1) The tearing test. The torn ends of linen appear unequal in length, parallel fibered and glossy. Cotton shows curling, lustreless threads of almost equal length. With practice it is possible to distinguish the sounds resulting from tearing the two materials; linen being shrill and cotton dull or muffled. (2) The oil

test. A piece of linen is freed from dressing by boiling in water or in a solution of soda. It is then saturated with oil and laid upon a glass and covered with a smaller piece of glass. All the surplus oil is now removed from the edges of the cover glass and the air bubbles are forced from the cloth. The cloth is now examined by letting the light fall upon the piece of cloth and by allowing the light to shine through the cloth. When the light falls upon it, dark spots like grease spots on paper appear, but when held between the observer and the light the linen cloth appears transparent. The opposite is true of cotton. (3) The acid test. A piece of linen, which has been thoroughly washed and is perfectly dry, is immersed in concentrated sulphuric acid for several minutes. It is then washed in water and dried between two pieces of filter paper. The cotton threads will dissolve almost completely while the linen fibers remain nearly unaffected.

Before being ready to be woven into cloth the raw material must go through several processes of preparation. Flax, which is grown for the fiber, is pulled from the ground instead of being cut. This is done in order that as long a fiber as possible will be obtained. The stems are then tied into bundles and dried. In some countries the sheaves are hung on fences or racks. In others they are kiln dried.

After the flax has been thoroughly dried it is *rippled*. In this process the leaves and seeds are removed by drawing the stalks through a large iron comb. The comb is fastened on a bench. Two workers sit at this bench, one at either end. A handful of flax is taken by each alternately and is thrown upon and drawn through the comb. The straw, as the material is now called, is then ready for *retting*. The object of retting is to separate the fine fibers from the woody bark and the core. The process is accomplished by fermentation. Retting may be done, first, by the cold water process, as in the running water of the river Lys, in Belgium, or in stagnant pools, as in Ireland; second, by steam or by the use of chemicals; and third, by dew, as practiced in parts of Germany and Russia.

The water of the river Lys is especially adapted for the retting of flax. Flax grown in Belgium and retted in this river is notable for its color, strength and fineness. The straw is placed in the water in open crates of wood. These crates are covered with jute burlap to keep out the dirt. The bundles of flax are stood on end and packed tightly in order to keep them from moving. From two to three thousand pounds are often put into one crate. The crates being filled and covered are weighted down with stone and sod until they are at least six inches below the surface of the water. The retting process is usually allowed to continue for a period of fifteen days. It takes longer to rett fine straw than coarse straw. When fermentation is completed several indications are noticeable, such as bubbles rising in the water, or the crate coming to the surface of the water. When

retting is finished the crates are pulled out and the bundles set out to dry. In Belgium the time for retting begins in March and continues until the weather gets too cold. When the straw has been thoroughly dried, during which stage the outer bark, the wood, and other hard parts of the plant become very brittle and the fiber elastic, it is ready for *breaking* and *scutching*. In the breaking process the straw is pounded with mallets or run through rollers which breaks all the hard parts of the stem. This being done the material is sent to a machine which scutches or scrapes the fiber, removing all the woody and hard parts. In some countries this is accomplished by hand and in others where the scutching is done in the mills, large paddles fastened to wheels are used.

The fibers are now baled and shipped to the mills for *hackling*, sometimes called combing. In this process the broken fibers of flax or tow, and the dirt are removed. Long fibers are called line and short ones tow, the former being used for fine cloth and the latter for inferior cloth. The fibers are now sorted into different grades and are run through a carding machine. The material comes out of this machine in long thread-like strands. After passing through another machine several of these threads are united and twisted together. The fiber is now ready for spinning.

Flax is spun in much the same way as cotton and worsted, excepting that the yarn often passes through a trough of hot water, as wet spinning makes a finer and more tightly twisted thread. On the other hand the thread does not have the silky appearance of the dry spun thread. The threads are now boiled, washed and rinsed several times. If white cloth is wanted it is spread out on the grass in the sun to bleach. Linen cloth is woven either bleached or unbleached, and may also be dyed.

CHAPTER VIII.

FOODS

BREAD MAKING*

BREAD is one of the foods we have on the table every day and for every meal. Some of it is made by the mothers at home but most of it comes from the bakery. Bread is made from flour, water, yeast and a little salt and sugar. These things are mixed together to make a dough. Yeast is used to make the dough rise so it will be soft and light. Salt and sugar flavor the bread and give it a better taste. If the ordinary yeast cake is used, the bread is started in the evening. The yeast cake is broken up and put into warm water. Then some flour and water are mixed, and the yeast and water are stirred into this. The mixture is then covered up and put in a warm place for the night. In the morning more flour and water are mixed, the yeast that was made the night before is stirred into it, and some salt and sugar are added.

The mixture is now left for a while in order that it may become light. It is the yeast that makes the dough light. After the dough has risen it is mixed some more and then left to rise again. The mixing is called kneading. After it has been mixed the second time it is molded into loaves and put into pans. The pans are greased before the dough is put into them in order that the dough may not stick. It is left to rise a short time in the pans. If the tops of the loaves are greased this will keep the crust from cracking when the bread is baking.

The pans containing the dough are put into a hot oven. If the loaves are small they will bake in a half hour. When the bread is done it should be taken from the pans at once. It should be allowed to cool before being cut. If properly baked the bread should have a thin, light-brown crust. It should be soft and light.

There are many kinds of bread. The names of some of them are: Boston brown, corn, French, graham, honey, macaroni, malt, rye, salt-rising, unleavened and Vienna.

Bread has more flour than other things in it. Flour is usually made from wheat. How wheat grows and how it is changed into fine white flour is as wonderful as a fairy tale. Each little grain of wheat grows into a great stalk. In the fall the farmer puts his wheat kernels into a machine called a drill. The drill drops the wheat on the ground and covers it up with warm earth. The seeds sleep in the ground for a few days, then the rain and sun come and the seeds wake

* This subject matter is written in story form suitable for use in Grade I.

up and grow. When the wheat first starts to grow the field looks like a green meadow.

But after a while the wheat plants stop growing and go to sleep under the warm, white blanket of snow. Here they sleep all through the cold winter. When spring comes and the warm rain falls once more, and the sun shines, the wheat starts growing again. It grows and grows until it is about three feet high. Then the warm summer sun turns the stalks from green to yellow, and the grain ripens. The farmer then drives into the field with a big machine which cuts the grain and ties it into bundles.

The bundles are then put into shocks which are left standing in the field; when the grain is quite dry the farmer hauls it to the barn. About three weeks later a big threshing machine comes to the farm. The bundles of wheat are now put into the machine which separates the straw from the wheat. The straw is blown into a stack in the barnyard, and the wheat kernels come out in a steady stream. They are caught in sacks and are emptied into a bin.

But people did not always have threshing machines to do the work so quickly. Long ago, when they wanted to separate the wheat from the straw they spread it out on the ground or on the barn floor and had oxen or horses tramp over it. Then they brushed the straw away and gathered up the wheat. Later the flail came into use. The flail was made of two pieces of wood hinged together by means of a strap. The farmer used the flail as a sort of club to separate the wheat grains from the straw.

After the threshing is over the farmer puts his wheat into sacks and takes it to the mill. At the mill steel rollers take the brown coats off the kernels and grind them into flour. The flour is sieved a number of times to separate the fine powder from the rough brown coverings. The flour comes out fine, soft and white, and it is put into sacks. Flour was not always made as it is today. Long ago people had no mills to grind it. They used to put the kernels of wheat on a stone that was hollowed out. Then with another stone they pounded and ground their wheat as fine as they could. This way of making flour took so long that people at last began to think of a quicker way. Then mills were built to grind the wheat. A large wheel turned by running water made the wheels of the mill go around.

The way flour is made today at the mills is still a better and a quicker way, for now mills are turned by steam power and nearly all the work of making flour from wheat is done by machinery. And bread is also mixed and prepared by machines.

DAIRYING INDUSTRY

Milk, and its products, butter, casein, cheese, condensed milk, form a very important part of our food. When we consider that the young of every species of animal are first supported by it, we must concede that it is the one food upon which life depends. Although the actual processes involved in the handling of milk commercially have been changed very little during the centuries, the emphasis is now upon securing sanitary conditions in the dairy and wherever milk is handled.

Modern dairy methods differ from the old, mainly in this demand for sanitation. It is now known that many of the impurities found in milk are deposited in it while it is being taken from the cow. Pure milk can be secured only from clean, healthy cows in well-drained, well-ventilated stables. Milk houses should be separate from the stables so that the danger of contamination is lessened. Milking machines are now being used extensively. Where men are employed to do this work good health, as well as absolute cleanliness of body and clothing, is required.

In the modern dairy every utensil is sterilized after using. Manufacturers of dairy utensils, recognizing this need of sterilization, make their utensils so that cleanliness can be easily secured. Before milk is delivered for use in the home it is thoroughly sterilized and put into bottles which are of the same temperature as the milk itself. These bottles are cleaned by hot water or steam and are sealed as soon as the milk is put into them.

Housewives are beginning to understand that the purity of the milk they use does not depend entirely upon the product which the dairy man delivers. Milk may be free from dirt or bacteria when taken into the home, yet careless exposure or dirty utensils will soon cause it to become unfit to drink.

Bacteria enter milk from the air or from articles with which it has come into contact, but cannot thrive in the milk in cold or hot temperatures. The housewife may make certain of the purity of the milk she uses by sterilizing it, thus killing the bacteria which cause poisons to form in the milk and which also cause it to sour. The sterilizing process is very simple; the milk is heated until it scalds, thus checking the growth of the bacteria colonies.

The first successful condensing process was discovered by Gail Borden in 1856. He used a vacuum-process by which the water was partially evaporated from the milk. In the Borden factories the milk is first tested for temperature and flavor and is then weighed. It is next run into large tanks where it is mixed with sugar. The milk and sugar mixture is put into vacuum pans and condensed. This discovery of the condensing process is of great importance, since it has supplied

a form of prepared milk which is strictly pure and which will keep for an indefinite period. In all factories for condensing milk, certain rules are observed which insure the purity of the manufactured product. All employees must be in good health, must wear sterilized garments and have clean personal habits. The manufacturers also demand that the dairymen who supply them with milk must keep their dairies open for public inspection; thus they are sure of absolute cleanliness of cows and dairy buildings.

Other forms of prepared milk are: (1) Pasteurized milk, which is sterilized by heating to a temperature of 150 degrees Fahrenheit in a period of from ten to thirty minutes and then quickly cooling, and (2) milk powder, which is milk from which all the water has been evaporated.

A very pure kind of milk is called *certified* milk, which is merely milk from tested cows in clean, healthy surroundings. These cows are inspected periodically by doctors and public inspectors, and are fed certain rations which are determined by experiments. Certified milk is important because it represents a movement looking toward government inspection of dairy herds.

MEAT PACKING

The subject of meat packing is interesting to us not only because meat is one of our important foods, but also because of its by-products. Some by-products which are made use of are: The blood for fertilizer, albumen and stock food, also for sizing paper and refining sugar; hides for leather; hair into camel's hair brushes and in shoddy, a sort of cloth; hip bones, horn and shoulder blades for hair pins, combs and buttons; thigh bones into tooth brush and knife handles; hoofs and scraps of hides, bones of hams for glue; tails give hair for cushions and mattresses; bristles for brushes; lining of pigs' stomachs for pepsin; fat for soaps and oleomargarine; dirt and refuse for fertilizer. Swift has done more than any other man in seeing that all parts are used.

Most of the American cattle are raised on the western plains, while the hogs are raised in the corn belts. When they are ready to be sold they are loaded and sent to market, the main market being Chicago. After they arrive at the stock yards they are unloaded into pens where they are inspected by government inspectors and then are sold to the highest bidder. Before the hogs are killed, cold water is turned on them and then they are fastened by a chain to a large wheel which raises them and places them head downward, automatically, on a hook which slides on a sloping rail. As they slide down this rail each man has his work to do, such as killing, placing in scalding vat, scraping and cutting up. These processes take about twelve minutes. The cattle are first killed by being hit in the head, then placed on the

sloping rail, where the different parts, such as the horns, hoofs and hide are taken off, and then cut in half. This takes twenty minutes.

They are then hung in the drying room for a few hours and next transferred to coolers of a temperature just above freezing. They are left there for forty-eight hours, or until they are ready to be still further cut up. Some of the parts into which a hog is cut are ham, shoulders, bacon and loins. The parts are graded, trimmed, cured, tested, branded (by paint), and smoked twenty-four to forty-eight hours. The parts to be sold fresh are sent to the different markets. Pork sausage is chopped, mixed and the skins stuffed by machinery. The fat of the hog is used for lard.

The beef is generally cut in half, then loaded in refrigerator cars and shipped to the markets.

If fish are to be sold fresh they are put on ice as soon as caught, but if not they are cared for in other ways. Cod fish are sometimes put in a brine, then later taken out and dried in the sun. Some fish are dried by being put on frames out in the open air, while others are pickled. Sardines are put up in olive oil, in flat cans, the little fish being laid close together. Fish are not only valuable as an article of food, but also for the oils and isinglass obtained from them.

CHAPTER IX.

A SUGGESTIVE LIST OF PROJECTS IN INDUSTRIAL ARTS FOR ELEMENTARY SCHOOLS

GRADE I.

BOOKS AND PRINTED PRODUCTS

The children make a collection of fragments of paper, cloth, wood, etc., upon which letters and designs have been printed. They observe the printed pages of their reading books and of magazines and newspapers. The concept of printing is formed.

PAPER AND PAPER GOODS

The small paper boxes used by commercial houses in the packing of goods are collected and brought to school. The uses of boxes and the making of them in factories is discussed. Paper boxes are made by the class, folding, cutting and pasting being the operations involved.

BREAD MAKING

The story of wheat and of bread making. The illustration of this story by drawings and the use of clay in modeling. The threshing of wheat by the children by rubbing heads of wheat in the hands; the grinding of wheat by means of stones or a mortar and pestle; the use of the flour thus made in the making of bread.

BRICK AND TILE

Pupils become familiar with brick and tile to the extent that they are able to identify them as building materials. They are able to pick out brick houses in pictures and on the streets. The class makes bricks of clay and builds little houses. Brick houses are also shown in imaginative drawings made by the class. This should be expression work in which the children are free to carry out their own ideas.

POTTERY

Why were articles of pottery first made? List the various articles of pottery and assign to each its use. Utensils of clay are made for the play house, *i. e.*, crocks, bowls, wash basins, bath tubs, etc. No particular method should be inflicted by the teacher; the children will prefer to make these articles by pinching the clay into appropriate shapes.

THE BUILDING OF A WOODEN PLAY HOUSE

Discussion of wooden buildings and their advantages and disadvantages over houses built of brick. Children in the first grade may profitably be given some instruction in the problem of housing. They investigate the work of the carpenter, visiting men at work on buildings in process of construction in the neighborhood of the school. Later each child makes a drawing to show how he would like his house to appear when finished. The best of these drawings are used by the children as guides. After all the materials needed are determined they are supplied and the children cut the boards into proper lengths, choose nails suitable for fastening the parts together, and go to work building the house. Not a nail is driven by the instructor nor are the children told where to place the nails. In the strictest sense the work is to be individual and original. The house is not built in a day; it usually requires about six weeks of persistent effort, thirty minutes each day being devoted to the work and its subject matter.

The workmanship upon buildings of this kind is crude enough—joints do not fit as we might wish they did. Yet when judged by the child's standards the house is quite perfect and beautiful; he has approached if not quite attained his ideal.

In work requiring that wood be cut and nailed by little children it has been found that wooden packing boxes serve well the purpose of benches. Carriage makers' clamps are substituted for vises. A few hammers, back saws, try squares, soap boxes, and our equipment is complete. Wood may be bought at the lumber yard in strips one inch wide; the material used for the clapboards is one-fourth inch in thickness, that used for the house frame is seven-eighths of an inch thick. Shingles are easily procured from the lumber dealer and a few pounds of nails varying in length from three-fourths to two inches may be obtained at the hardware store.

The fine thing about a problem of this kind is that the children gain so much in the ability to express their own ideas through action. They also learn valuable facts relating to house building and house furnishing. The expense involved is slight as compared with the educational returns.

After the house has been enclosed it is painted with real house paint and the rooms decorated with furnishings made by the children.

GRADE II.

BOOKS AND PRINTED PRODUCTS

A book is made by folding a long strip of paper several times, vvvvv. Attention is called to the fact that the first books with pages were no more than this. A collection of pictures is made, all bearing

upon a single subject and printed upon paper. These pictures are pasted into the book thus formed by the folded strip of paper, great care being exercised in the placing of each picture upon the folded page form. The name of the book is printed on the outside sheet, which serves as a cover, the teacher printing the title suggested by the class upon the blackboard, and the pupils following his lettering, line for line.

BRICK

The story of brick making is told in simple language by the teacher and the children are asked to illustrate each a certain part of the story. Such subjects as the following are suggestive: (1) Men getting clay from the ground. (2) Men molding bricks. (3) Men carrying bricks to the fire for burning. (4) Men burning bricks.

POTTERY

The teacher tells the story of primitive pottery or the children read it in their reading books. The story is illustrated on the sand table, where the primitive industry is being carried on by little clay men, represented as being engaged in digging and preparing materials, in making pots, and in firing the ware.

GRADE III.

BOOKS

The story of ancient book making in China and Japan. Advantages and disadvantages of the Japanese type of book. The making of a Japanese book. Materials: Two cover boards of strawboard, 3¾ in. by 6¾ in.; two pieces of strawboard for laced back, 1 in. by 6¾ in.; one piece of cloth for cover hinge, 4 in. by 14 in., (this will make two hinges 4 in. by 7 in.); two pieces of colored paper to cover strawboard covers, 6 in. by 7¾ in.; four pieces of paper for cover lining, two pieces 3½ in. by 6¼ in., and two pieces ¾ in. by 6¼ in.; twenty pieces of paper for leaves, 6¾ in. by 11 in. Each of the leaves is folded as follows: One of the short edges of the sheet is folded over one inch and the paper is creased. The opposite short edge of the paper is now folded over to this crease. After the pages and covers have been prepared they are punched for the laces. There may be either an odd or an even number of punched holes. The book is now laced. An ordinary shoe lace or a piece of colored cord will serve this purpose. The leaves are left uncut.

BRICK AND TILE

The modern methods of brickmaking as compared to the methods followed by the ancient Egyptians and by the American Indians, who built houses from bricks of adobe. The class will make little bricks. From these they will construct an adobe house with a roof of thatch. Material for the roof can be procured out of doors, *i. e.*, small twigs, grasses, etc.

MAKING BRICKS AND BUILDING A SMALL HOUSE

The house is to be built in city block style, *i. e.*, with solid side walls, windows and doors in front and back, and sloping flat roof. It is to be rectangular in plan, and one side will be left open.

The class may be divided into groups, each group being held responsible for a particular part of the work, and yet permitting of enough freedom that each benefits by the others' work. The spirit of competition will be conducive to better work. The following are the groups to be provided:

1. Clay diggers and mixers.
2. Molders.
3. Driers and firers.
4. Masons.
5. Carpenters.

Plan the house in the class room, each pupil drawing a set of floor plans. These plans are to be made for a real, full-size house and drawn to such a scale that one-fourth inch on the plan represents one foot on the actual house. The house should be built on a scale of about one inch to a foot. That is, every dimension which would be one foot on a real house will be one inch on the house built by the children. The actual building of the house should be done outside the school house, and here the work by groups will begin. They will work as follows:

1. Clay diggers and mixers:—Dig the clay (in the school yard if possible, or it may be obtained from a builder, a cart load being sufficient for the whole project). Then grind and mix the clay in a wooden mixing box in which an improvised narrow tread roller may be run back and forth. Such a roller can be made by casting a concrete wheel and providing it with a suitable handle for moving; or a discarded iron wheel of some sort may be used. The mixing box is to be built by the carpenters and is of plain box-construction. Mix the clay with water until it is very fine and plastic.

2. Molders:—First construct, with the aid of the carpenters, a number of molds. These may be either unit or multiple molds. In either case they should provide a rectangular box form for the brick which will be one-half inch thick, one inch wide and two inches long.

In either case also, the bottom should be removable, and a *pusher* should be provided by means of which the clay may be pushed from the mold in the form of a brick. Then proceed to mold the bricks by pressing the mold full of clay and packing it well. Remove the bricks from the molds and give them to the driers.

3. Driers and firers:—Take the bricks from the molders, spread them on a board and allow them to dry in the sun. Then pile them in arch-like piles, preparatory to firing. Build fires under and around the arches and tend these fires until the bricks have been properly hardened. It will be necessary to bring the bricks to a red heat and to keep them at this temperature for perhaps half an hour.

4 and 5. Masons and carpenters:—These groups will work together a great deal. Stake off for the beginning of the building. Mix cement mortar (it will be best to use pure cement for this, for while sand and cement are generally used, it may be found difficult to get satisfactory bonding qualities when children of this age are using it). Such a mixture of cement and water is known technically as *neat cement.* Proceed to lay the bricks, breaking joints, and avoiding an excess of mortar. The carpenters will make the window frames and door frames (which may be simple rectangular frames of the sizes required) and will help the masons set them in place. Make the second floor of a solid board and set in place at a proper height on a ledge, provided by laying bricks on edge instead of flat in this layer, thus leaving a difference in the thickness of wall of one-half inch, which, if the outside of the wall is kept in line, will provide the ledge on the inside. The floor board should be one inch thick (the same as the height of this layer of bricks) so that the next layer of bricks may be laid flat and will rest flat on the floor board. Make the roof of a solid board and cover with sanded tar paper.

POTTERY

It is possible that clay suitable for the making of dishes may be found in the vicinity of the school building. Ask the children to look for it. The soil is brought into the school room in lumps which are broken and the large stones and roots removed. It is now placed in a large pail partly filled with water, and the mass stirred. The mud being thoroughly mixed to the consistency of a thick cream is poured through a screen into a second pail. The small stones are in this way removed.* An ordinary window screen may be used, although a finer sieve is desirable. After settling over night the clear water is poured off and the clay spread out in the sun to dry sufficiently for

* The clay may be dried and put through the screen dry. This method, although not according to industrial practice, may be found to be better adapted to the school conditions.

use. Before being used, however, it is made plastic by working a few minutes in the hands.

Designs for the vases are worked out by folding and cutting pieces of paper. In this way silhouette patterns are easily produced. The form should be kept simple, the sides nearly vertical. The silhouette is transferred to drawing paper, tinted to match the color of the clay after it has been fired. A decorative border or surface design involving the repetition of a unit may be worked out with tempera water color paints or with colored crayons. The colors used may be: (1) The color of the clay after firing. (2) Yellow-red. (3) Red. (4) Black.

The dishes will be made by building by the use of clay coils rolled between the hands and the desk top, which is protected by a sheet of linoleum, a board, or a piece of heavy paper. A pasteboard disk having the same diameter as the base of the proposed vase form is used as a guide in starting. This is covered with a disk of clay about three-sixteenths of an inch thick, and the building of the walls is accomplished by the spiral arrangement of the clay coil which is welded to itself at each complete revolution by being pressed firmly against the growing wall. The clay should be kept in a plastic condition. If the walls become unsteady because of their moist condition and the weight of the clay, the form should be set aside to become *leather-hard* when the building may be continued. Before continuing, however, the rim of the dish, formed by the last coil, should be cut squarely off with a knife and a thick mixture of clay and water, called *slip*. applied with a bristle brush. A mucilage brush will answer the purpose. When the form has been entirely built it is scraped off and carefully trued with a knife and with sandpaper. The design may now be incised by means of a knife or the point of a nail, while the clay is still soft. The parts to which color is to be applied are now brushed over with slip just before the color is applied. The slip is brushed on and the color applied immediately. Pigment colors for application to the clay may be produced by reducing rotten stones of various colors to powder by means of a hammer, or better, by mortar and pestle. The colors are mixed with a small proportion of clay which will bind them to the body of the dish; or more attractive colors may be bought at the paint or drug store. The colors are mixed with liquid glue and are painted upon the moist clay in the form of a thick paste. It is a good idea to scratch the surface of the clay with a pin or piece of broken glass before painting the ware as this will improve the bonding quality. Yellow ocher is used for yellow-red, red oxide of iron for red, and black oxide of copper for black.

In firing pottery of this kind it is not necessary to have a kiln in order to do satisfactory work. Dishes made in school should be

preserved by firing because an industrial process is thereby made clear to the child, and because the dishes thus made are useful and therefore practical. Iron kettles placed in an open fire of wood will make it possible for the children to fire their pottery after the Indian or open fire method, the kettles keeping the burning embers from falling upon and thus breaking the dishes. The kettles, therefore, should be covered in order that the dishes shall not be broken. The heating and cooling should be gradual, the dishes being kept at a red heat for about an hour.

If there is no clay at hand it may be ordered from a school supply house. A low temperature clay which will stand the fire should be specified.

In connection with the study of pottery it is suggested that the class collect illustrations in which articles of pottery are advertised. These pictures can be mounted on large cards and the dishes illustrated compared. The forms should be judged from the standpoints of utility and of beauty. Articles of pottery or fragments of pottery may also be collected to illustrate earthenware, stoneware and porcelain.

GRADE IV.

BOOKS AND PRINTED PRODUCTS

A comparative study of the methods of bookmaking which obtained during the middle ages and those of today. How are we affected by books and other publications? What would happen if there should be no more printing? Imagine the world without any facilities for printing for the period of one year, beginning today. What would be the result?

To make a book of a single signature.

The cover boards will be $\frac{1}{8}$ in. wider and $\frac{1}{4}$ in. longer than the page, in order that the covers may project beyond the pages. The size and proportions will be determined to suit the purpose for which the book is to be made. The book described below is suggested as suitable for the mounting and preserving of reproductions of masterpieces in art.* Each picture is mounted on a page of odd number, while the story regarding it is written on the page at the left or a page of even number. The mounting of the pictures and the arrangement of written material, the observing of proper margins according to the best typography, etc., are problems in design involving the division of space. Procedure: (1) Choose a rectangular piece of strawboard large enough to make one cover board. (2) Place the

* Such pictures may be obtained from The Perry Pictures Company of Malden, Massachusetts.

same on the desk so that it lies vertically in reference to the edge of the desk nearest you, which is horizontal. (3) Place the ruler on the strawboard along the upper edge. (4) Measure 6⅝ in. from the left corner and place a point. (5) Place ruler on desk just below the lower edge of strawboard and place a point on this edge 6⅝ in. from the left edge. (6) Draw a line connecting this point with the one on the upper edge. (7) Place ruler on left edge of strawboard and measure down on left edge 8½ in. from upper corner and place a point. (8) Measure down on pencil line 8½ in. from upper edge and place a point. (9) Connect this point last made with that on the left edge of the strawboard. (10) Cut out cover board. (11) Lay out and cut second cover board. (12) To lay out linen back measure off on back of material, dimensions in the manner given above, getting out the bookbinders' linen 5 in. by 9½ in. (13) Draw a center line lengthwise of this material. (14) Draw lines across either end parallel with and ½ in. from the short edges of the material. (15) To prepare cover papers 5⅝ in. by 9½ in. measure as suggested above. (16) Paste linen back to cover boards, leaving ⅜ in. between the boards (the thickness of the book will determine this measurement). (17) Paste cover paper to cover boards, cutting corners on mitre and then pasting down laps. (18) Count out half as many papers as there are to be leaves in the book. (There should be a supply of paper stock for this purpose cut 8½ by 13½ in.) (19) Measure and cut this paper into pieces 8¼ in. by 13 in. (20) Fold each sheet to make two pages, 6½ by 8¼ in. (21) A piece of ordinary linen cloth is now prepared for holding the covers to the leaves of the book. It is measured and cut one-half inch shorter than the length of pages (or 7¾ in. long and 4 in. wide). (22) Draw a center line lengthwise of this material. (23) Place pages together and stab or pierce for sewing. Stabbing may be accomplished by means of a fine awl or coarse needle. (24) Place linen outside of folded pages, its center line lying along the stabbed holes, and sew the pages and linen together, the needle first entering the center stabbed hole, proceeding to one end of the row of stabbed holes then back to the opposite end, and so on to the center, where the knot is tied. (25) Fasten the *signature* or section of pages to the cover boards by pasting the linen to the cover boards, being careful to center signature at back, in reference to cover boards. (26) Paste down end sheets (the leaves next to the covers).

Caution: The worker should have at hand a pile of flat papers about 9 in. by 12 in. Torn newspapers will serve the purpose. These papers are to protect the work as it is being put through the various processes of pasting. The papers should be stacked before the pupil who keeps his work upon the uppermost piece which is always clean, since he crumples the papers and drops them on the floor as soon as they become soiled with paste or glue. Papers are also used under the

hand when rubbing one pasted paper upon another. At the close of the period the crumpled papers are picked up and put in the waste paper basket.

PAPER AND PAPER PRODUCTS

The evolution of writing materials. A comparative study of early and modern methods of paper making. The pupils are asked to bring clean scraps of white cloth, and the other things needed. *The making of paper.* The following directions will guide the teacher in carrying out the project: (1) Tear the rags into little bits about one-half inch square or even smaller. (2) Twelve ounces of caustic soda* are dissolved in six quarts of water. (3) The fine bits of cloth are stirred into this. (4) The caustic soda solution, containing the rags in suspension, is boiled for three or four hours. This may be done out of doors if no stove is at hand. (5) Rinse rags thoroughly in three waters, pouring the mixture into a colander and wringing the rags each time. (6) Dry the rags, spreading them out in shallow tins or upon boards where they may better come in contact with the air. (7) Run dry rags through meat chopper, which will reduce them to a fine pulp. (8) Put pulp into a wash of six quarts of water, containing eight tablespoonfuls of starch, one of bluing, and one-half pint of liquid glue. (9) *Agitate* the wash by stirring with a paddle or stick, and while the pulp is held in even suspension in the water, dip in the mold, a screen the size of the proposed sheet of paper. (This screen is made by stretching an ordinary wire fly screen over a small wooden frame.)

When the screen is lifted out the liquid will be allowed to drain back into the tank. (10) Turn the thin layer of pulp which has been deposited on the screen into a shallow dish. (A pie tin will answer this purpose.) A piece of cheese cloth should first be placed in the dish in order to prevent the pulp from sticking fast to the dish. (11) Cover this first layer of pulp with a small piece of cheese cloth. (12) Deposit a second layer of pulp; cover with cheese cloth, etc., until the desired number of sheets has been provided for. (Each child in turn will deposit his layer of pulp and a cover of cheese cloth upon the pile.) (13) Apply pressure to pile. This may be done by placing it in a standing press or letter press. Or the pressure may be applied by means of clamps or hand screws, or by the use of weights, such as bars of iron, heavy stones, etc. The water will run out as the pressure is applied. A few holes may be made in the tin dish which contains the pile of pulp. (This may be easily accomplished with a

* CAUTION:—Caustic soda or sodium hydroxide comes in stick form and is poisonous. It should be provided and cared for by the teacher.

hammer and nail.) The water is caught in a pail as it is squeezed out.

The sheets of paper are now removed, each on its piece of cloth, and are placed in a row to dry.

POTTERY

Modern commercial methods of making rectilinear clay dishes.

The making of a design for a square dish or jardiniere for flowers.

The jardiniere may be elevated upon four feet, one at each corner, if desired. It may be glazed if equipment for glazing and firing is at hand. The side of this flower dish will furnish a problem in design involving an application of the principle of *balance*, bi-symmetrical or free. Proportions will be determined first, after which will come the consideration of the placing and shape of legs, the decoration and color. The design will be incised by means of a sharp instrument (a nail will answer the purpose). The motive for design may be suggested by natural forms such as flowers, fruit, birds, etc., or it may be geometric. The design should emphasize the shape and surface of the dish. The class will work with colored crayons, striving to represent correctly the color of the clay. If colors are to be employed in decoration, the scheme of color should be *analogous, i. e.*, colors lying next to one another in the color circuit, as blue and blue-green; blue-green and green; green and green-yellow, etc.

The making of a square flower dish using slabs of clay to form the walls and bottom.

The sides and bottom will be made separately (five pieces). These parts will be *welded* together by means of a mixture of clay and water, *slip*. Surfaces to be united by welding are first covered over with slip applied by means of a bristle brush (an ordinary mucilage brush is excellent for the purpose). The surfaces are immediately united by being pressed firmly together and tapped with finger tips to increase the bond.

A brief study of glazes is taken up. The story of Palissy the Potter is read by the class or is told by members of the class, who have read it.

The dish may be fired according to the open fire method described for Grade III, or in the school kiln, if such is provided.

DAIRY INDUSTRY

During the study of dairying, charts are prepared which help to clarify the concepts of utensils and processes and furnish opportunity for vital instruction in art. The class is encouraged to bring material,

such as pictures, advertisements, labels, etc. The instructor aids in the selecting and grouping of these upon the chart by suggestions only. The material is arranged by the children.

One chart might be labeled Dairy Products and all pictures and other material illustrative of this topic mounted on it. Little bottles of milk, cream, butter, buttermilk, cheese, malted and condensed milk, could be displayed effectively in this way. Another chart might be designated Dairy Utensils and illustrations of the various utensils used in the dairy would be arranged on it. Miscellaneous pictures of the dairy and its utensils and machines could be grouped on still another chart entitled The Dairy.

The cardboard used in mounting should be rather large, 20 in. by 24 in., or even larger. The cord employed in hanging charts and in fastening the bottles and other objects in place should be of the same *hue* of color as the chart itself, which should be of a low color *chroma* of yellow-red, green, blue, etc. The titles for these charts should be printed by the children. Pieces of paper, of the same hue as the mounting board chosen, but of a lighter *value*, cut to occupy the space required for the printed title, are prepared by the children, who are left to determine size and proportion. The best size and shape being decided upon by the class, each pupil prepares a strip of paper of the adopted shape and size and prints upon it the title for the chart. The most satisfactory printed title is now chosen and the pupil making it is allowed to paste it in place. Each chart is thus prepared by the class, the articles being first pinned in the places where they appear to the best advantage, and then pasted. Equal margins are observed at the left and right, and suitable margins are left at the top and bottom.

Chart making will be found an effective means of vitalizing subject matter and of sustaining interest. The work will throughout its progress enable the pupils to select material bearing upon a single subject and to arrange this material to the best advantage, considering the relative importance of the units and their best artistic arrangement. The finished charts will be hung in the school room where the class may see the combined result of their efforts.

Drawings made by the children might also be mounted on still another chart. These drawings should include free representations of the utensils used in dairying.

The making of butter.

While the dairying industry is being investigated the process of butter making can be clarified by the making of butter. All the materials and many of the utensils should be furnished by the children.

If dairy utensils cannot be obtained, improvised utensils can be used with equally satisfactory results. A glass fruit jar, having a tightly

fitting cover, can be used in churning and is easily handled by the children. While using these improvised utensils, the teacher should constantly refer to the practical dairy utensils, thus giving the pupils a correct idea as to the utensils as well as the process of butter making.

The cream is first allowed to sour, then it is poured into the real or improvised churn. If a fruit jar is used as a churn the churning is accomplished by the shaking of the jar. When the butter has been formed, the buttermilk is poured off and strained. The butter is then worked, salted, and set in a cool place to harden. A little bottle of this product should be placed on the Dairy Products chart, and the remainder may be given to the pupils to eat on crackers at recess in order that they may judge the result of their work. The utensils emphasized in this work are: The churn or jar, the wooden bowl and mixing paddle, and the crock.

Each child should be given a task to perform so that the process will be understood by all. The work of preparing materials, washing utensils, and churning should be shared by all the pupils.

Butter making provides a splendid opportunity for the teacher to emphasize sanitation. All utensils should be carefully washed and sterilized, and then kept covered until used. The source and growth of bacteria colonies should be carefully explained in order that the pupils will understand why these precautions are necessary.

This project can be used as a means of motivating lessons in drawing, spelling, language and arithmetic. The utensils can be drawn and the drawings mounted on the chart; the names of the utensils can be used as spelling words; arithmetical problems, and compositions can be woven about the industry. The educational value as well as the interest and enjoyment afforded will convince one that the time devoted to work of this kind is well spent.

GRADE V.

BOOKS AND PRINTED PRODUCTS

A comparative study of early and of present day methods of printing by means of movable types. The story of John Gutenberg and his printing press is read before the class by pupils to whom this reading has been assigned.

A simple booklet is made in which will be preserved information relative to the subject of printing. A visit to a small job printing shop should be arranged if possible, and an account of the visit written for the booklet, which should also contain drawings made to illustrate: (1) The first printing press. (2) Type. (3) Hand lettered alphabet. (4) Printed books. These drawings should indicate that pupils understand the principle that surfaces viewed at an angle appear to be

narrower from front to back than they actually are. This is the principle of *foreshortening*. Examples of good typography, cut from magazines and newspapers, may also be mounted and kept in the booklet.

The construction of the project need not be elaborate. The pages, perhaps 7 in. by 9 in., are fastened together by punching and lacing. A piece of flexible paper will serve as a cover. A simple cover design appropriate to the subject of printing, is made. This design will include: (1) A marginal line. (2) The title and the name of the author in free hand lettering. (3) An appropriate spot or unit which may symbolize a printing press, a printer at work, a shelf of books, etc. The design for the unit will be transferred to a linoleum block (a block of soft wood about an inch in thickness to which a piece of linoleum, perhaps three-sixteenths of an inch in thickness, has been glued). The linoleum is cut away from those parts of the design which are not to print. A pad of cheese cloth is made by rolling up a strip of the material so that at least four thicknesses are piled one upon another. Over this pad is poured a mixture of liquid glue in which water color paints have been mixed. If the mixture is too stiff, a few drops of water are added. By the use of this ink pad and the linoleum block the unit design is printed upon the cover in the place where it will appear to the best advantage. *A complementary color scheme* should be used, the color employed in the printed unit being the complement of that used in the marginal line and lettering, as for example, yellow and purple-blue, red and blue-green, yellow-red and blue, etc.

Posters offer excellent opportunities for combining instruction in industry and art. In the making of a class poster all members of the class are provided with linoleum blocks just alike. An entire alphabet is cut, each pupil cutting a letter. Each member of the class now makes a small poster design and the most satisfactory one is chosen for the large class poster. The large poster is printed, each pupil inking and impressing a letter in turn, the pupils being arranged in line, type blocks in hand, to spell out the words needed. Such work will require careful supervision. It is well to appoint two pupils to act as foremen. The letters forming the words should be placed close together and the spaces between the words should be equal. The printed lines can be kept straight by means of thumb tacks and strings. The principle of *balance* should be observed in the arrangement of printed matter upon the page. A pad of soft papers, placed underneath the poster paper will facilitate the printing.

The motive for making a poster might well be the advertising of an entertainment or other school function.

THE MAKING OF A BOOK OF SEVERAL SIGNATURES

In the making of a book of eight *signatures* the following steps will be followed: (1) Cut eight pieces of paper 8 in. by 12 in. for the leaves. (2) Place the sheets in a stack on the desk with the longer dimension along the edge of the desk nearest you. (3) Fold the back edge of the top sheet over toward you, to the edge of the desk, and crease. (4) Fold the right edge of this folded sheet over toward the left, to within one-sixteenth inch of the left edge, and crease. (The one-sixteenth inch is allowed for the next folding, as will be seen after the next operation.) (5) Fold the sheet again, as before, this time bringing the right edge over to the left edge. All edges at the left should now be even. The folded signature should measure 3 in. by 4 in. (6) Number the pages in this first signature, placing numbers on both sides of each page, as in a commercial book. Open out the sheet and note the arrangement of the pages as numbered. Were this to be a printed book these numbers would guide the printer in arranging his type. Fold the signature together as before. (7) Fold the seven remaining sheets in the same way. (8) Take the first signature and place your ruler so that it lies along the folded edge, the edge which will later be at the back of the book. Measure from one end of the signature, along this folded edge, the following distances (without moving your ruler from its original position) and place points: $\frac{1}{4}$ in., $\frac{3}{4}$ in., 1 in., $1\frac{1}{2}$ in., $1\frac{3}{4}$ in., $2\frac{1}{4}$ in., $2\frac{1}{2}$ in., 3 in., $3\frac{1}{4}$ in., $3\frac{3}{4}$ in. These are the points through which the needle will pass in sewing the signatures to the *lay cords*, cords which in turn will be laced into the covers, thus fastening them to the book. (9) Place the signatures in a stack as they will be arranged in the book, placing the first signature on top. Number the signatures, using small Roman numerals. Number pages consecutively from the first signature to the end of the book. (10) Mark the folded edge of each of the signatures in turn, for sewing, using the first signature as a pattern. (11) Punch holes for sewing. This may be done with a large needle or awl. (12) Provide four lay cords, each of which will be seven inches long. Shoe laces are excellent for this purpose, although any strong cord will do. (13) Start sewing the first signature to the lay cords. The progress of the needle will be as follows: Into the hole nearest one end of signature; to next hole; through hole to outside of signature; around first lay cord to next hole; through hole into signature; on to next hole; and through hole to outside of signature; around second lay cord and into signature as before, etc., until the last hole has been reached. (14) Place second signature in position for sewing. The progress of the needle will be as before, except that the direction will be reversed. When the needle has

reached the hole above the first hole entered in the first signature a knot is tied to further strengthen the union of the first two signatures, the loose end projecting from the first signature being tied to the thread extending through the corresponding punched hole in the second signature. The sewing of the third signature is continued as before, the direction of the needle being reversed. When the last signature has been sewed to the lay cords a final knot is tied to further strengthen the union of the last two signatures. (15) The back of the book is now rounded by pressing the front edges of the signature with the thumbs, and the book is placed in a vise or under a weight. (16) Glue is now spread over the back of the book, care being taken not to get any glue on the lay cords where they are to act as hinges for the covers. (Lay cords with glue on them are liable to break off when the covers are opened.) Leave book under pressure until glue hardens. (17) Cut two cover boards $3\frac{1}{8}$ in. by $4\frac{1}{4}$ in. from strawboard or heavy pasteboard. (18) Place covers in position, allowing them to project one-eighth inch beyond the front, top and bottom edges of the book. The space between the back of the book and the cover boards will be allowed for the working of the hinge. (19) Mark points on cover boards to indicate the positions of the lay cords, placing these points in, one-half inch from the long edge of the cover boards. (20) Punch the cover boards at these points to admit the lay cords which will enter from the outside of the book and will be glued to the inside of the cover boards. (These holes may be punched or pierced with an awl.) (21) Cut a piece of linen or other thin cloth 3 in. by 5 in. for hinge. Fold in at each end one-half inch of this material and paste down upon itself. (22) Paste this hinge along the back of book, centering it with back of book. (23) Place book between the covers, lace the cords through from the outside, and glue the lay cords to the inside of cover boards; also paste linen hinge to inside of cover boards. (Avoid getting paste on the parts of linen which are to act as hinges.) (24) Cover back of book with bookbinder's linen, pasting the same to cover board, but not to the back of the book. This material must be cut for fitting to the back of book. (See Grade IV book project, under Books and Printed Products.) (25) Cover the cover boards with cover paper (see Grade IV, project). (26) Prepare two end sheets 6 in. by 8 in., and fold them into double sheets 3 in. by 4 in. These end sheets may be decorated by an all over surface pattern design printed with wood block, if desired. (See Grade V., Books and Printed Products.) (27) Paste in end sheets, so adjusting them that the covers may be opened and closed without difficulty. (28) Put book in press, or beneath weights.

BRICK AND TILE

A study of modern brick and tile making. Small pieces of wood, small nails and a hammer will be given to each pupil who will endeavor to contrive and construct a brick-making machine, the function of which shall be: (1) To form clay into strips which are oblong in section. (2) To provide for cutting this strip of clay into small pieces, thus forming the bricks. The bricks will be made by forcing clay through the mold; the bricks are cut off with a piece of wire. They can be fired in an open fire out of doors.

CASTING OF LEAD PAPER-WEIGHT

A project which illustrates the characteristics of lead and at the same time gives an insight into the industrial processes of pattern making and metal casting is the making of a lead paper-weight or of some other simple article which is easily cast in this metal. In carrying out the project it will be necessary first to construct a *molding flask*. This is easily accomplished by fifth grade pupils. The flask is made as follows:

It consists of two box-like frames, just alike, two inches high, four inches wide and six inches long (inside dimensions), and a *bottom board* one inch thick, six inches wide and eight inches long. The two frames will be placed one on top the other on the bottom board, the upper frame being known as the *cope* and the lower as the *drag*. In order that these two parts of the flask shall come together in the same position each time it will be necessary to provide some sort of registering device. This may be done by nailing three strips (about one-half inch thick, one inch wide, three inches long) on the outside of the cope, two on one side and one on the opposite side, so that the ends of the strips project down the sides on the outside of the drag, and by nailing similar pairs of strips to the sides of the drag so that there is a strip on each side of the one projecting from the cope. When the two parts of the flask are brought together they must always be in such position that the strip projecting from the cope will fit between those fastened to the drag.

A pattern is now constructed. This pattern will be an exact model, in wood, of the article to be cast. The sides of the pattern are tapered, however, the pattern being smaller at the top than at the base. This tapering is called *draft*, and is put on the pattern to facilitate drawing the pattern from the sand, as will be seen later.

The molding flask is in three parts—the cope, the drag and a board. In making the mold, or *molding*, as it is called, the pattern is placed, large side down, on the board. The drag is placed over or around it. The drag is then filled to the top with damp mold-

ing sand, or any very fine sand, well *tamped*. Another board is placed on top of this and rubbed gently so as to make an even, compact surface on the sand. The drag is then turned over and the board removed so that the pattern is now exposed. The cope, or upper portion of the flask, is then fitted to the drag. A layer of fine, dry sand, technically known as *parting sand*, is then sprinkled over the exposed surface of damp sand in the drag. Then the cope is filled with the damp molding sand, well tamped. A pin, called the *sprue pin* is set up in the sand so that it projects into the sand in the drag at a point conveniently near to the position of the pattern in the sand. The sprue pin is a tapered cylinder. For this small work a new stick of chalk will answer the purpose very well. The sand in the cope is packed around this pin and the pin is then withdrawn, leaving a hole through the sand in the cope to the drag and a little way into the drag. A small channel is now cut from the end of the *sprue hole* to the cavity left by the pattern. This channel is called a *gate*. To do this latter operation it is necessary to lift the cope off of the drag. The pattern is removed by driving lightly into it a sharpened nail, tack, or any other instrument which may serve as a handle for withdrawing the pattern. It is now evident that unless the pattern were larger at the base than at the top it would be very difficult to withdraw it without breaking the sides of the mold left by it in the sand. To allow for the escape of steam which will be formed when the hot metal is poured into the damp sand mold, *vents* are made in the sand of the cope by punching a nail or pin nearly through the sand of the cope. The cope and drag are then fitted together again and all is ready for the pouring.

The lead may be melted in an iron pot on an ordinary stove. It should be poured slowly but steadily into the sprue hole until the latter is completely filled. After allowing sufficient time for cooling, the casting may be removed from the flask and the sand cleaned from it. The projection of metal from the gate may be removed by breaking, and then filing the casting smooth.

GRADE VI.

BOOKS AND PRINTED PRODUCTS

The linotype machine, stereotyping and electrotyping as means of making type arrangements permanent. If possible, a visit to an up-to-date newspaper or publishing house should be arranged.

The instructor may illustrate the process of stereotyping in the following manner: (1) Obtain from Grade V a linoleum print block which has been made by a pupil of that grade, or make such a block by cutting a letter in relief. (See Grade V.) (2) This block will be the pattern from which it is desired to make a matrix, or form for casting type. Pack pulp (made by soaking paper in water) around

means of crayons or water color paints. The principles of *adaptation* and *interrelation of units* may thus be provided for in design, while *chroma* or strength of color will be emphasized in the making of appropriate color combinations.

In the weaving of rattan baskets the reeds perform two functions: those which form the skeleton frame-work are called *spokes*, while those which pass in and out, thus filling in between the spokes, are called the *weavers*. Large diagrams placed upon the blackboard to illustrate the method of starting the basket will be found helpful in teaching the operations of construction. The instructor should also start a basket before the class.

The rattan should be moistened before using, but it should not be put into hot water nor soaked for more than half an hour. The reeds to be used as spokes should be cut to the proper lengths and tied together in bundles before wetting; reeds to be used as weavers are coiled and tied before soaking. The worker should keep his fingers moist by occasionally dipping them into water.

In making a rattan basket from five inches to eight inches in diameter it is advisable to use No. 4 rattan for the spokes and No. 2 for the weavers. The basket maker takes four spokes in each hand, and, pressing these flat so that they lie beside one another, he places the four spokes held in the right hand upon the four held in the left hand. The groups of four reeds each are now made to cross each other at right angles, the point of intersection being midway from end to end on each group of reeds. A half-length spoke is now placed beside one group of four and the weaving is begun, the weaver proceeding over and under each spoke, there now being in position seventeen spokes projecting around the center. When the start has reached a diameter of five or six inches a new spoke is inserted beside each of those already in position excepting the last, there now being thirty-three spokes in all. The basket is carried to completion. To finish the rim, bring each spoke around the two following it, and into the basket, moistening the reeds, pulling them in place, and pressing them tightly upon the last weaver.

In making a basket from rattan and raffia it is possible to employ one of several satisfactory stitches. The one which makes the firmest basket is perhaps the stitch known as *figure-of-eight*, so named because the raffia describes this figure as it passes in and out in the process of sewing, 8. The basket is formed by coiling a piece of rattan, covering it with raffia and at the same time sewing it to itself as the process of coiling progresses. The extreme end of the rattan, which has been thoroughly soaked, is first bent to the form of a hook; then the raffia is wrapped about this and the coiling-sewing process begins. A fine tapestry needle is used for sewing, and the raffia is split, in order that the sewing may be facilitated, and is worked dry. The

the block in order to get an accurate impression of all, including the letter and entire block. (3) Remove the print block from the pulp which has now been made to conform to its shape. (4) Allow this pulp box or matrix to dry. (5) Pour molten lead into the matrix. If poured very slowly the metal will run down into all the edges of the inside of the form. (6) After the lead has hardened and cooled the pulp may be scraped off. (7) The face of the piece of type thus cast is now finished with a file.

HOLLOW TILE

Hollow tile manufacture. The making of hollow tiles 1 in. by 1¼ in. by 2 in., by means of a simple wooden mechanism constructed by the pupils. The firing of the tile. The planning and erecting of a small model building, such as a house, barn, or garage. The making of the plan will involve a study of building plans (some of these should be brought to school by pupils), and the drawing of a plan to scale.

The hollow tile made in school will serve as the building material. The binding paste will be common lime mortar, which is made by combining lime, sand and water. The advantages and disadvantages of lime mortar will be discussed; the proportioning of the quantities of materials will be based on volume, *i. e.*, one part lime, two and one-half parts sand, two and one-half parts water. The materials are measured out and kept separate. A large pan serves as a mixing box. A bed of sand is made in the pan and the lime distributed as evenly as possible over it. The entire amount of water is now sprinkled over the lime and the remainder of the sand sprinkled over this. It is advisable to cover the pan in order to retain the vapor given off while the lime is being *slaked*. The wet materials are now left undisturbed for at least twenty-four hours before they are mixed together. The mixing may be done with a small trowel or a broad knife. The mixing process should be thorough, an even paste resulting.

BASKETS

A comparative study of the following as materials for basket making: Strips of ash, oak strips, willow, rattan. Investigation of a modern basket factory through visiting or correspondence.

The designing of a small basket to be made either of rattan covered with raffia or of rattan only.

Pupils should be allowed to choose which type of basket they would rather make. A silhouette or outline pattern is obtained by folding and cutting. The outline is then transferred to a sheet of drawing paper and the design colored, if raffia is to be used, by

means of crayons or water color paints. The principles of *adaptation* and *interrelation of units* may thus be provided for in design, while *chroma* or strength of color will be emphasized in the making of appropriate color combinations.

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figure-of-eight is simply an over-and-over stitch, the progress of the needle being: (1) Between reeds and into basket. (2) Around outside reed and into basket. (3) Around inside reed and out of basket, and repeat. This project may be vitalized by a study of the primitive peoples who engaged in basket making.

CONCRETE CONSTRUCTION

The making of a small rectilinear concrete box.

Portland cement and its use in the making of concrete. Sources of material. The uses to which concrete is put, etc.

The following steps of procedure will be observed: (1) Determine use of box and its dimensions. No dimension shall exceed five inches. The walls and bottom will be three-eighths inch thick. (2) Make a working drawing of box, representing three views. (3) When the box is cast in concrete it will be necessary to use a clay *core* to provide for the shape of the inside of the box. Make a working drawing of this core, using the inside dimensions of box as dimensions for the core. (4) Compute in cubic inches the total volume of box, solid. (5) Compute volume of core. (6) Find difference between these two quantities, which will give the cubic content of the walls and bottom of box. (7) Allowing one-fourth of this volume for loss when materials are mixed (the cement filling the voids between the grains of sand), determine the number of cubic inches of material needed. (8) Four parts of cement will be used to one part of sand.* How much cement will be used? How much sand? (9) Make core of moist clay. (10) The box will be cast with the mouth down, or in an inverted position. Place core on a piece of board, putting a sheet of paper, or better, waxed or stencil paper, under the clay to prevent concrete from sticking and the wooden board from warping. (11) Prepare outer walls of *form*, building them of clay about one-half inch in thickness, leaving a full three-eighths inch between the core and the walls, carrying the walls up a little over three-eighths inch above the top of core in order to provide for bottom of box. (12) Construct a measure in the form of a one-inch cube, for cubic measure. Use heavy paper and provide laps for gluing. (13) Measure out the cement and sand, placing these materials in a shallow dish (a pie tin makes a good mixing pan). (14) Mix the materials dry, and then slowly add water while mixing until the mixture is just thin enough to pour. (A broad knife is a good tool for mixing.) (15) Strengthen the clay form by piling clay about it on the outside.

* White Portland cement and marble dust may be substituted for these materials if the same can be obtained from the dealer. Boxes made of the marble are more attractive than those made with sand.

(16) Pour the concrete mixture into the form, over the core, being careful to avoid air bubbles. (17) *Tamp* with knife, being careful not to disturb core. (18) Place long wire nails across core in order to *reinforce* the box at the bottom. Do not allow nails to project to within more than one-fourth inch of the form walls. (19) Put away to *set*. The cement will begin to harden within half an hour. Damp cloths should be thrown over the form at the end of an hour from time of pouring. This will prevent the evaporation of the water and will thus facilitate setting. The form should now not be disturbed until at least two days have elapsed. (20) Carefully remove outside clay form and dig out clay core. (21) Smooth outside of concrete box by rubbing it over a piece of No. 3 sandpaper, being careful not to break it as it is still quite soft. (22) Make on paper, using pencil, a simple border design in line, adapting it to the purpose of decoration. (23) Scratch this design upon the box with a sharp wire nail. (24) Place completed box in a pail of water to become as hard as rock. The more time allowed for this process of *curing*, the better. Three days, however, will be found sufficient. (25) Remove box from water. (26) Drain water out of it and allow all moisture to dry out of walls and bottom. (27) Paint box, if desired, with Toch's cement filler* or with any other suitable cement varnish. If a dull finish is desired, the hard varnish can be sandpapered with No. 00 sandpaper.

PLASTER MOLDS FOR POTTERY CASTING

The method employed in industry for making any number of cups or vases, all just alike. Sources of material. Location of the places where the industry is carried on.

To make a plaster mold from a small bowl or cup, the same to be without a handle and to have no flange or projecting rim at the bottom.

Pupils bring cups from home for the purpose of making the molds. The processes involved are as follows: (1) Invert cup upon a small piece of board which has been covered over with a piece of stencil or oiled paper. (2) Roll a piece of heavy flexible paper into the form of a belt, perhaps one inch wider than the height of the dish for which the mold is to be made, and long enough to encircle the dish, leaving at least one inch between the belt and the dish all the way round, and tie together with a piece of string. This belt will serve as an outside form wall. (3) Strengthen wall by banking clay around it on the outside. (4) Prepare size by putting a piece of soap, as large as

* Toch Bros., 320 Fifth Avenue, New York City.

a walnut, into a dish containing one-half pint of water. The water is heated and the soap allowed to simmer in it until entirely dissolved. The size is now allowed to cool. When cool it should be of the consistency of molasses. (5) A coat of size is now applied with a brush to the entire surface of the inverted dish. It is well to go over the dish twice to make sure that all parts have been covered. (6) Plaster-of-Paris is now mixed for pouring. For every quart of water 2¾ pounds of plaster should be used. Plaster is thrown into water, a handful at a time, until the required amount has been put in. The plaster is now allowed to soak for a couple of minutes, when the hand of the worker is plunged into the mixing dish and the plaster thoroughly stirred to the consistency of cream. The mixture is soon felt to thicken. When it has become as thick as a thin batter it should be poured at once over the inverted cup, care being taken to cover all parts of the surface and to fill the form to the top of the wall. Air bubbles must be broken or kept from being poured into the form. (7) The work is now left for a few minutes, while attention is given to the mixing dish which must be rinsed out at once before the plaster *sets*. The rinsing water is carried out of doors as the pouring of it into a sink will stop up the drain pipes. (8) The process of hardening, called setting, began as soon as the liquid plaster was poured into the form. In about ten minutes from the time of pouring, the plaster will begin to *heat*. This warmth indicates the completion of setting. (9) The form is now removed and the sides of the plaster mold trued with a knife. This is easily done as the walls are still quite soft. (10) The plaster cast is now turned over, the cup removed, and the mold put away to dry. It is most important that all of the water should dry out of the plaster.

TO CAST A SMALL BOWL OR CUP BY MEANS OF A PLASTER MOLD

Cups are cast by pouring a mixture of clay and water, called slip, into plaster-of-Paris molds. It is convenient to make this slip in small quantities, several pupils being engaged in the work. Large bowls or pails are used for mixing. Into a quart of water, which may be warmed if desired, is placed a large lump of clay, which has been kneaded to a thoroughly plastic condition. The clay is now mixed with the water, which the worker accomplishes by constantly squeezing the lumps of clay at the bottom of the mixing dish until they almost disappear, the mixture of clay and water getting thicker and thicker as additional particles of clay become suspended in the water, until the consistency of batter is reached. The slip is now poured through a sieve to remove any remaining lumps of clay.

The plaster molds, which are to be poured, are now arranged

in a row. Two pouring dishes should be provided for the slip. Tin cans bent to facilitate pouring, or pitchers, may be used. Before using the slip, however, it should be slowly poured back and forth from one pitcher to the other in order to break any air bubbles, which are likely to form in all newly prepared slip.

Each plaster mold still retains some of the soap size which must be removed before it can be used. It is therefore cleansed by being filled with the slip, which is at once emptied out. It is then allowed to stand for ten minutes in order that the water may be absorbed from the clay, which has been deposited upon the walls. This thin lining of clay is now picked out by means of a small piece of plastic clay, which is pressed against it. The thin clay coating will readily adhere to the piece of moist clay. If all of it can not be taken out in this way it may be wiped out with a piece of cloth. After cleaning, the form should again be allowed to dry out thoroughly.

The plaster molds are again arranged for pouring and each is poured brimful of slip, which is allowed to round over the opening in a little mound, which gradually sinks lower and lower into the form as water is absorbed into its plaster walls. After the last form has been filled it is likely that the first will be ready for refilling. The process of filling is continued, each of the forms being kept brimful. After all have been kept full for a couple of minutes, the blade of a broad knife may be scraped across the brim of the first form in order to ascertain the thickness of the clay wall which has been drawn to the inside of the plaster form, this clay deposit forming the wall of the dish which is being cast. A thickness of one-eighth inch is desirable. If the walls have not attained this thickness the pouring must be resumed.

The plaster form is now carefully lifted and the free slip poured out. Each form is inverted upon two sticks or pencils in order to provide for circulation of air under it. A small quantity of slip will drip from the form before the drying begins. Forms should be left inverted and undisturbed, for at least an hour, at the end of which time the first may be examined for removal. If the drying has progressed far enough the clay wall will be found to have shrunken slightly from the plaster. The newly cast dishes are put aside to dry. After they have become quite dry they may be finished by the use of sandpaper. They are then fired.

WORKING SHEET COPPER

A project that will illustrate some of the characteristics of copper, is the making of a small pin tray or other form of tray. The material to be used will be 18-gage soft sheet copper. A piece is cut out about half an inch larger than the finished tray is to be. Then on the edge of a piece of wood beat down the depression desired in

the tray with a hammer. Cut away the rough edges to the desired outline and lap over or beat back the edges. This consists simply of beating the edges of the tray with a hammer, causing the metal to become somewhat thicker at the edge, and giving it a more finished appearance. If the tray is to be a round one the method is as follows: Cut out of 18-gage soft sheet copper a circle one-fourth inch larger in diameter than the plate is to be; next lap over the edge one-eighth inch all around the flat piece of metal, or beat it back. Next beat down the depression in the plate. To do this, first draw a line with a pair of compasses where the depression starts; then hold the plate on the end of a block of wood and beat it down over the edge of the block with a hammer along the pencil line. If the plate is to have a deep depression, it will be necessary to *anneal* it, because it becomes hard while being beaten. This is done by heating it to a red heat in a gas or other flame, then cooling it in water. (The cooling in water does not have the effect of hardening copper as it does steel or iron but softens it.)

If desired, the brim of the plate may have a border design *etched* on it. This must be done before the depression is beaten down, however. The design is painted on with asphaltum varnish, as are all parts of the plate which are not to be touched in the etching process by the acid. The whole is placed, when dry, in a solution of one part nitric acid and two parts of water in a stoneware or glass dish. The acid will, in a few minutes, begin to *etch* or eat away the metal that has been left bare. After it is etched deep enough, (which will take anywhere from thirty minutes to three hours, according to the depth desired) take the plate out of the acid and remove the asphaltum varnish by scraping it off with a scrap of copper, or by soaking it for about a half hour in turpentine, gasoline, or a solution of lye, when it will readily wipe off.

PROJECTS IN TIN

For a project involving the use of sheet iron and tin, the making of a sugar scoop, or a tin cup is most appropriate. A satisfactory way to construct such utensils is to make use of empty fruit or milk cans which may easily be cut to the desired shape, and a handle made and soldered on as required. The making of cookie cutters presents another good field for operation. The tin needed for these articles may be obtained from various sorts of tin cans and boxes. Opportunity for individual expression will be afforded, and at the same time the qualities and characteristics of tin will be illustrated. The use of the alloy of tin and lead, viz., solder, will be involved also.

INDUSTRY CLASSIFICATION*

GROUPS

I. STONE, CLAY AND GLASS PRODUCTS.
II. METALS, MACHINERY AND CONVEYANCES.
III. WOOD MANUFACTURES.
IV. FURS, LEATHER AND RUBBER GOODS.
V. CHEMICALS, OILS, PAINTS, ETC.
VI. PAPER.
VII. PRINTING AND PAPER GOODS.
VIII. TEXTILES.
IX. CLOTHING, MILLINERY, LAUNDERING, ETC.
X. FOODS.
XI. WATER, LIGHT AND POWER.

GROUP I.

STONE, CLAY AND GLASS PRODUCTS

1. Stone
   - (a) Crushed stone
   - (b) Cut stone

Building Stone	Plumbers' marble
Grindstones	Pumice stone
Hones	Roofing slate
Marble cutting and polishing	Slate blackboards
Marble mosaics	Soapstone
Monuments	Tombstones
Oilstones	

2. Miscellaneous Mineral Products
   - (a) Asbestos, graphite, etc.

Carbons	Mica
Feldspar	Parting spar
Foundry facings (graphite)	Talc

   - (b) Abrasives

Carborundum	Emery paper
Emery	Sandpaper

   - (c) Composition roofing

3. Lime, Cement and Plaster
   - (a) Asphalt
   - (b) Cement
   - (c) Lime
   - (d) Plaster

Gypsum	Plaster-of-Paris
Land plaster	Wall plaster
Plaster board	

* Adapted from Industrial Directory of New York State, 1913 edition, issued by the Department of Labor, Albany, N. Y.

GROUP I., STONE, CLAY AND GLASS PRODUCTS—*Concluded*

3. LIME, CEMENT AND PLASTER—*Concluded*

(e) Artificial stone

Composition articles of cement
Concrete blocks

(f) Plaster and composition casts and ornaments

Clay models
Stucco work

(g) Mortar and sifted sand

4. BRICK, TILE AND POTTERY

(a) Brick, terra cotta and fire-clay products

Building brick
Drain tile
Enameled brick
Fire-brick
Floor tile
Mosaics (ceramic)
Ornamental brick
Paving brick
Sewer pipe
Stove linings
Terra cotta
Vitrified brick

(b) Pottery products

China decorating
China ware
Crockery
Dolls (china and porcelain)
Earthenware
Porcelain insulators
Porcelain ware
Stone ware
White ware
Yellow ware

5. GLASS

(a) Building glass and glassware

Blown glassware
Bottles
Bulbs
Chimneys
Crown glass
Flasks
Insulators (glass)
Jars
Lamps (glass)
Lamp shades (blown)
Plate glass
Pressed glassware
Stained glass (exclusive of cutting and leading)
Table ware
Tubes
Vault lights
Window glass
Wire glass

(b) Mirrors

(c) Cut and ornamental glass

Art glass (reworking)
Beveled glass
Decorated glass
Engraved glass
Glazing
Labels (glass)
Lamp shades (leaded)
Leaded glass
Reworking of glass
Signs (glass)
Stained glass (exclusive of blowing)

GROUP II.

METALS, MACHINERY AND CONVEYANCES

1. GOLD, SILVER AND PRECIOUS STONES

(a) Gold and silver refining

Assaying
Smelting

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Continued*

1. GOLD, SILVER AND PRECIOUS STONES—*Concluded*

(b) Silverware

Plated table and toilet ware	Silversmithing
Silver deposit ware	Table ware
Silver plating	Toilet ware

(c) Gold and silver leaf

Dental gold

(d) Jewelry

Diamond setting and mounting	Mountings
Enameling on jewelry	Thimbles
Engraving on gold or silver	Umbrella handles (gold and silver)
Gold pens	Watch cases
Mesh bags (gold and silver)	Watch repairing

(e) Lapidary work

Diamond cutting and polishing (exclusive of setting and mounting)

2. BRASS, COPPER, ALUMINUM, ETC.

(a) Smelting and refining.

Analysis and experiments with metals	Solder
Babbitt metal	

(b) Copper goods

Sheet copper	Wire (copper)

(c) Aluminum goods

Aluminum leaf	Sheet aluminum
Castings	

(d) Brass and bronze goods

Auto horns	Locks (brass)
Bells	Pipe
Brass spinning	Polishing
Carburetors	Rods
Castings	Sheet brass
Electric fixtures	Tubing
Furniture (brass)	Valves (brass)
Gas fixtures	Wire (brass)

(e) Sheet metal work of copper, brass and aluminum

Brass Stencils	Fire extinguishers (brass, copper, etc.)
Coppersmithing	Household ware of brass, copper, etc.

(f) Lead, zinc and nickel goods

Brazing	Plating (unspecified)
Die castings (soft metal)	Sheet lead
Galvanizing	Sheet tin
German silver	Tin foil
Lead pipe	Type
Nickel plating	White metal

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Continued*

2. BRASS, COPPER, ALUMINUM, ETC.—*Concluded*

(g) Miscellaneous metal novelties

Buttons (metal)
Combs (metal)
Corset findings (metal)
Fishing reels
Glove fasteners
Hooks and eyes
Needles
Paper clips
Pins
Toys (metal)

3. IRON, AND STEEL PRODUCTS

(a) Ore crushing

(b) Pig iron

(c) Rolling mills and steel works

Horse shoes
Plates
Rails
Rods
Wire
Wire cables
Wrought iron pipe

(d) Structural and architectural iron work.

Bridges
Fire escapes
Grilles
Ornamental iron work
Railings (iron)
Safes
Stairs (iron)
Vaults

(e) Forgings

Axles (exclusive of car axles)
Boiler tubes (welded)
Chains
Horse nails
Springs (exclusive of wire springs and car springs)
Wagon springs
Welding

(f) Sheet iron work

Cornices
Enameled signs
Enameled ware
Granite ware
Japanning
Metal stamping
Metallic caskets
Metallic doors and house trim
Stamped ware
Tin bottle caps
Tin cans
Tin lithographing
Tin toys
Tinware
Umbrella frames

(g) Hardware not elsewhere classified

Bolts
Brackets
Carriage hardware
Casters
Game traps
Hames
Iron toys
Locks (other than brass)
Nails
Nuts
Pipe bending and fitting
Pulley blocks (iron)
Saddlery hardware
Sash balances
Screws
Signs (metal)

(h) Cutlery

Carving sets
Knives
Razors
Scissors
Shears

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Continued*

3. IRON AND STEEL PRODUCTS—*Continued*

(i) Implements and tools

Bakers' tools
Chucks
Confectioners' tools
Garden rakes
Hammers
Hoes
Manure forks
Picks
Pitchforks
Plumbers' tools
Scoops
Screw drivers
Shovels
Soldering irons
Spades
Wrenches

(j) Edge tools, dies, etc.

Augers
Axes
Bits
Chisels
Files
Gimlets
Hatchets
Jewelers' tools
Planes
Pruning knives
Rasps
Saws

(k) Firearms

(l) Metal furniture and office fixtures

Bed springs
Spring beds
Wire mattresses

(m) Wire work

Bird cages
Coat hangers
Hat frames
Piano wires
Wire springs (exclusive of bed springs)

(n) Car wheels and railway equipment

Air brakes
Brake beams
Brake shoes
Car axles
Car springs
Couplers (car)
Railway signals (exclusive of electric)
Trucks

(o) Cooking, heating and ventilating apparatus

Air registers
Exhaust systems
Furnaces
Radiators
Ranges
Stoves
Ventilators

(p) Typewriting and registering machines

Adding and computing machines
Addressing machines
Canceling machines
Car registers
Cash registers
Check protectors
Duplicating machines
Numbering machines
Telegraph typewriters
Voting machines

(q) Engines, boilers, etc.

Air compressors
Fire-engines
Gas engines (exclusive of automobile engines)
Ice machines
Marine engines
Steam pumps
Steam rollers
Steam traps
Tanks (boiler iron)

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Continued*

3. Iron and Steel Products—*Concluded*

(r) Machinery not elsewhere classified

Acetylene generators
Bookbinding machinery
Bottling machinery
Brick machinery
Buffing wheels
Canning machinery
Coffee machinery
Conveying machinery
Elevators
Gears
Grain cleaning machinery
Grinding machinery
Hoisting machinery
Hydraulic jacks
Lathes
Laundry machinery
Merry-go-rounds
Paper and pulp machinery
Polishing wheels
Printing presses
Pulleys (belt)
Punch presses
Road-making machinery
Sewing machines
Shafting
Shoe machinery
Stamping machines
Stone crushers
Textile machinery
Type setting and casting machines
Vacuum cleaners
Vending machines
Woodworking machinery

(s) Castings

Cast iron pipe
Hydrants
Steel castings
Valves (iron)

4. Electrical Apparatus

Annunciators
Arc lamps
Auto starters (electric)
Batteries
Bells (electric)
Burglar alarms
Dynamos
Fans (electric)
Fire-alarm apparatus
Incandescent lamps
Insulated wire and cable
Magnetos
Motors
Signs (electric)
Spark plugs
Switchboards
Telegraph apparatus
Telephone apparatus
Tickers
Transmitters
Transformers

5. Vehicles

(a) Carriages, wagons and sleighs

Baby carriages (iron)
Baggage trucks (exclusive of electrics)
Carriage bodies
Carriage repairing
Hand trucks
Painting (carriage and wagons)
Trucks (bag and barrel)
Wagon rims
Wheelbarrows
Wheels (wagon and carriage)

(b) Bicycles, motorcycles and parts

Aeroplanes
Bicycle and motorcycle repairing
Bicycle wheels
Coaster brakes

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Continued*

5. VEHICLES—*Concluded*

(c) Automobiles and parts

Auto bodies
Auto painting
Auto repairing
Baggage trucks (electric)
Engines (automobile)
Motor trucks
Radiators (automobile)
Tire chains
Transmissions
Wheels (automobile)
Wind shields

(d) Cars

(e) Locomotives

(f) Railway repair shops
Street railway repair shops

6. BOAT AND SHIP BUILDING

Repairing

7. AGRICULTURAL MACHINERY

Brooders
Corn huskers and shredders
Corn shellers
Cream separators
Cultivators
Ensilage cutters
Evaporators
Fanning mills
Fence machines
Grain drills
Grubbing machines
Harvesters
Hay forks (horse)
Hay loaders
Hay presses
Hay tedders
Incubators
Land rollers
Lawn mowers
Lime spreaders
Manure spreaders
Mowing machines
Plows
Potato diggers
Pumps (exclusive of steam pumps)
Reapers
Scythes
Seeders
Sprayers
Stanchions
Threshing machines
Wind mills

8. INSTRUMENTS AND APPLIANCES

(a) Professional and scientific instruments.

Barometers
Compasses
Dental appliances and supplies
Engineering instruments
Meteorological instruments
Nautical instruments
Surgical instruments
Surveying instruments
Thermometers
Thermostats

(b) Optical and photographic apparatus

Artificial eyes
Cameras
Eye-glasses
Lenses
Microscopes
Spectacles
Telescopes

GROUP II., METALS, MACHINERY AND CONVEYANCES—*Concluded*

8. INSTRUMENTS AND APPLIANCES—*Concluded*

   (c) Lamps, reflectors, stereopticons, etc.

   Auto lamps
   Calcium lights
   Lanterns
   Locomotive headlights
   Motion picture machines
   Railway signal lamps

   (d) Clocks and time recorders

   (e) Scales, meters, etc.

   Balances
   Gas meters
   Speedometers
   Steam gauges
   Water meters

9. SORTING OLD METAL

GROUP III.

WOOD MANUFACTURES

1. SAW MILL PRODUCTS

   Dressed lumber (manufactured in saw mills)
   Excelsior
   Kindling wood
   Lath
   Resawing
   Rossed wood.
   Shingles

2. PLANING MILL PRODUCTS

   (a) House trim

   Blinds
   Creosoting lumber
   Doors
   Dressed lumber (manufactured in planing mills)
   Fireproofing lumber
   Last blocks in the rough
   Mouldings
   Office partitions
   Sash
   Veneer

   (b) Packing boxes, crates, etc.

   Cheese boxes
   Egg cases
   Fruit baskets
   Shooks

   (c) Cigar and fancy wood boxes

   Jewelry cases (wood)

3. COOPERAGE

   Barrels
   Churns
   Heading
   Hogsheads
   Kegs
   Pails (wood)
   Staves
   Tubs

4. MISCELLANEOUS WOOD ARTICLES

   Artificial limbs
   Baby carriages, (wood and rattan)
   Blackboards (wood)
   Blocks (children's)
   Canes
   Carved woodwork
   Chair legs
   Checkers
   Chopping bowls

GROUP III., WOOD MANUFACTURES—*Continued*

4. Miscellaneous Wood Articles—*Concluded*

- Clothes pins
- Crutches
- Dishes (wood)
- Doll carriages (wood)
- Dominoes
- Excelsior pads
- Express wagons
- Fishing rods (wood)
- Games (wood)
- Handles (wood)
- Hat blocks
- Ladders
- Lasts (wood)
- Patterns (wood)
- Pulley blocks (wood)
- Rulers (wood)
- Scroll sawing
- Signs (wood)
- Sleds
- Spools (wood)
- Step-ladders
- Table legs
- Tennis rackets
- Toothpicks
- Toys (wood)
- Turned woodwork
- Umbrella sticks
- Wagon hubs
- Wagon spokes
- Wood heels
- Woodenware
- Yardsticks

5. Furniture and Cabinet Work

(a) Furniture and upholstery

- Bamboo furniture
- Mattresses (exclusive of hair and wire)
- Reed furniture
- Willow furniture

(b) Desks and office furniture

- Filing cabinets (wood)

(c) Cabinet work and fixtures

- Bank fixtures
- Bar fixtures
- Barbers' chairs
- Billiard tables
- Bowling alleys
- Butchers' blocks
- Carpenter work (unspecified)
- Carpet sweepers
- Church seats
- Clothes-wringers
- Dentists' chairs
- Dumb waiters
- Grilles
- Ice cream freezers
- Kitchen cabinets
- Parquet floors
- Plumbers' woodwork
- Pool tables
- Refrigerators
- Revolving doors
- Saloon fixtures
- Show cases
- Stage properties and scenery
- Stairs
- Store fixtures (exclusive of furniture)
- Telephone booths
- Wash-boards
- Washing machines
- Wood mantels

(d) Mirror and picture frames

(e) Caskets

6. Pianos, Organs and Other Musical Instruments

- Banjos
- Drums
- Flutes (wood)
- Guitars
- Mandolins
- Piano actions
- Piano cases
- Piano keys
- Pipe organs
- Players (mechanical)
- Violins

GROUP III., WOOD MANUFACTURES—*Concluded*

7. PENCILS, PIPES, CORK, BROOMS, RATTAN AND FIBER GOODS

(a) Pulp and fiber goods

Fiber pails
Wall board

(b) Mats, baskets, etc.

Grass manufactures
Rattan goods
Reed ware
Straw goods (exclusive of hats)
Willow ware

(c) Brooms

Brush brooms

(d) Cork cutting and cork goods

(e) Smoking pipes

Meerschaum pipes

(f) Pencils and pen holders

GROUP IV.

FURS, LEATHER AND RUBBER GOODS

1. LEATHER

Leather board (of scrap leather)
Salting hides
Skivers

2. FURS AND FUR GOODS

Dressed furs
Fur caps
Fur dyeing
Fur garments
Fur gloves
Fur hats
Fur robes
Hatters' fur
Taxidermy

3. LEATHER AND CANVAS GOODS

(a) Leather and canvas belting, hose, washers, etc.

(b) Saddlery and harness

Automobile tops (leather)
Dashboards
Fenders (leather)
Halters
Horse blankets
Whips

(c) Traveling bags and trunks

Instrument cases
Medicine cases

(d) Boots and shoes

Cloth and carpet slippers
Leather slippers
Leggings (leather)
Moccasins
Sandals
Shoe repairing

(e) Leather gloves and mittens

GROUP IV., FURS, LEATHER AND RUBBER GOODS—*Concluded*

3. LEATHER AND CANVAS GOODS—*Concluded*

(f) Miscellaneous leather goods

Auto fittings (leather)
Base balls
Belts (leather)
Caps (leather)
Card cases
Chair seats (leather)
Chamois underwear
Dog collars
Drum heads
Embossing leather
Hand bags
Hat bands
Pocket books
Razor strops

(g) Canvas and sporting goods

Automobile tops (cloth)
Awnings
Burlap bags
Canvas bags
Oiled clothing
Sails
Tarpaulins
Tents
Window shades (cutting, etc.)

4. RUBBER AND GUTTA PERCHA GOODS

Atomizers
Boots (rubber)
Combs (rubber)
Dental rubber
Fountain pens (rubber)
Gas tubing
Hose (rubber)
Mackintoshes
Mats (rubber)
Packing (rubber, rubberized canvas, etc.)
Penholders (rubber)
Phonograph records
Rubber bands
Rubber brushes
Shoes (rubber)
Stamps (rubber)
Stoppers (rubber)
Tire vulcanizing
Tires (rubber)
Tubing (rubber)

5. PEARL, HORN, BONE, CELLULOID, HAIR, ETC.

(a) Buttons and other articles of pearl, celluloid, etc.

Billiard and pool balls
Combs (exclusive of rubber)
Composition buttons
Composition dolls
Ivory
Knife handles
Music strings (gut)
Shell
Sponges
Whalebone

(b) Brushes

(c) Articles of hair, feathers, etc.

Feather dusters
Hair mattresses
Pillows
Switches

GROUP V.

CHEMICALS, OILS, PAINTS, ETC.

1. DRUGS AND CHEMICALS

(a) Proprietary medicines

Patented medicines and pills
Plasters (medicated)
Salves

GROUP V., CHEMICALS, OILS, PAINTS, ETC.—*Continued*

1. Drugs and Chemicals—*Concluded*

(b) Chemicals

Acids
Alcohol
Alkalies
Alum
Ammonia
Baking powder
Bleaching materials
Boiler compound
Calcium carbide
Caustic soda
Coal-tar products
Compressed gases
Cyanides
Disinfectants
Gas mantles
Insect powders
Liquefied gases
Metal polish
Pharmaceuticals
Potash
Saltpetre
Soda
Sulphur
Tanning extracts
Washing fluids
Welding compound

2. Paints, Dyes and Colors

(a) Paint, varnish, etc.

Colors in oil
Dryers
Enamels
Fillers
Furniture polish
Japans
Kalsomine
Lacquers
Lead oxides
Putty
Red lead
Shellac
White lead
Whiting

(b) Dyes, colors and inks

Blacking
Bluing
Butter color
Carbon paper
Dry colors
Lampblack
Printing ink
Shoe polish
Stove polish
Typewriter ribbons

3. Wood Alcohol and Essential Oils

Castor oil
Charcoal
Coke
Cotton-seed oil
Flavoring extracts
Glycerine
Linseed oil
Olive oil
Peppermint oil
Pitch
Rosin
Turpentine

4. Animal and Mineral Oil Products

Axle grease
Candles
Gasoline
Grease
Leather dressing
Naphtha
Oil pumping
Paraffine
Petroleum
Tallow
Wax

5. Soap, Perfumery and Cosmetics

Cold cream
Hair tonic
Toilet powder
Tooth powder and paste

GROUP V., CHEMICALS, OILS, PAINTS, ETC.—*Concluded*

6. Miscellaneous Chemical Products

(a) Starch

(b) Glue, mucilage, etc.

Fly paper	Paste
Gelatine duplicators	Sizing

(c) Fertilizers

(d) Matches and explosives

Ammunition	Gunpowder
Fireworks	

(e) Photographic supplies and photography

Blue print paper	Photographic film
Dry plates	Photographic materials (chemicals)
Lantern slides	Photographic paper
Motion picture film	

GROUP VI

PAPER

1. Sorting Waste Paper

2. Pulp and Paper

Builders' paper	Strawboard
Cardboard	Surface coated paper
Glazed paper	Waxed paper
Leather-board (of wood pulp)	

GROUP VII.

PRINTING AND PAPER GOODS

1. Paper Goods

(a) Paper boxes and tubes

Butter dishes (paper)	Jewelry cases (paper)
Corrugated paper	Letter files (paper)
Egg carriers (paper)	Ribbon blocks

(b) Paper bags and sacks

(c) Miscellaneous paper goods

Card cutting	Paper flowers
Cups (paper)	Patterns (paper)
Envelopes	Perforated music
Gummed paper	Photo-mounts
Label cutting	Sample cards
Lace and shelf paper	School globes
Paper and cardboard signs	Stationery
Paper cutting	Toilet paper (cutting, etc.)

GROUP VII., PRINTING AND PAPER GOODS—*Concluded*

2. Printing and Book Making

- Addressing and mailing
- Albums
- Blank books
- Bookbinding
- Calendars
- Electrotyping
- Embossing
- Engraving
- Games (printed)
- Linotype composition
- Lithographing
- Music engraving and printing
- Numbering paper
- Paper ruling
- Photo-engraving
- Photogravures
- Playing cards
- Post cards
- Printers' rollers
- Publishing
- Stereotyping
- Tip printing
- Typesetting
- Wood engraving

3. Wall-Paper

Wall-paper sample books.

GROUP VIII.

TEXTILES

1. Silk and Silk Goods

(a) Broad silks

- Chiffon
- Lace (silk)
- Plush
- Ribbon
- Taffeta
- Thread (silk)
- Twist
- Veiling
- Velvet
- Yarn (silk)

(b) Silk knit goods and gloves

- Gloves
- Hosiery
- Neckwear (knit)
- Underwear (manufactured by textile concerns)

2. Wool Manufactures

(a) Carpets and rugs

(b) Felt and felt goods

- Felt shoes
- Paper makers' felt

(c) Woolens and worsteds

- Cassimeres
- Cheviots
- Flannels
- Shoddy (wool)
- Tweeds
- Union and cotton mixed goods
- Waste (wool)
- Yarn (wool)

(d) Wool and felt hats

3. Cotton Goods

- Cotton batting
- Grain bags
- Sheeting
- Shirting
- Shoddy (cotton)
- Thread (cotton)
- Twine (cotton)
- Waste (cotton)
- Yarn (cotton)

GROUP VIII. TEXTILES—*Concluded*

4. COTTON AND WOOLEN HOSIERY AND KNIT GOODS

Gloves (exclusive of silk)
Sweaters
Underwear
Wristers

5. OTHER TEXTILES OF SILK, WOOL OR COTTON

(a) Dyeing, finishing, etc.

Bleaching
Cloth examining
Mercerizing
Printing
Refinishing
Sponging
Waterproofing

(b) Curtains, embroideries and dress trimmings

Bindings
Braids
Corset laces
Embroideries (machine)
Fringes
Lace (exclusive of silk, linen and hand)
Lace curtains
Passementeries
Shoe laces

6. FLAX, HEMP AND JUTE MANUFACTURES

(a) Linen manufactures

Crash
Lace (exclusive of hand)
Linen fabrics
Thread (linen)

(b) Cordage and twine

Binder twine
Fishing twine
Hammocks
Nets
Oakum
Rope
Seines

(c) Jute manufactures

Bagging
Burlap
Carpets (jute)
Rugs (jute)

7. OILCLOTH, ETC.

Buckram
Imitation leather
Linoleum
Window shade cloth

GROUP IX.

CLOTHING, MILLINERY, LAUNDERING, ETC.

1. MEN'S GARMENTS AND FURNISHINGS

(a) Men's tailoring

Alterations (on men's clothing)
Buttonholes
Cleaning and pressing (men's clothing, by tailors)
Coats
Overalls
Overcoats
Pants
Uniforms
Vests

(b) Men's shirts, collars and white goods

Barbers' coats
Bath robes
Bathing suits
Butchers' aprons
Butchers' coats
Cuffs
Pajamas
Underwear (exclusive of knit)

GROUP IX., CLOTHING, MILLINERY, LAUNDERING, ETC.—*Continued*

1. MEN'S GARMENTS AND FURNISHINGS—*Concluded*

(c) Men's furnishings

Garters	Suspenders
Neckwear (exclusive of knit)	

(d) Boys' tailoring

Coats	Knee pants
Jackets	Overcoats

(e) Boys' Waists

Blouses	Wash suits

(f) Raincoats

Men's, women's and children's

2. WOMEN'S GARMENTS AND FURNISHINGS

(a) Women's cloaks, suits and skirts

Alterations (on cloaks, suits and skirts)	Plaiting
Cloaks	Skirts
Jackets (women's)	Suits (women's)

(b) Women's white goods

Aprons	Lingerie
Brassiers	Petticoats (muslin)
Hemstitching (for dresses)	Tucking

(c) Negligee and petticoats

Bath robes	House dresses
Bathing suits	Kimonos
Dressing sacques	Petticoats (silk and wool)
Gymnasium suits	Wrappers

(d) Women's dresses and waists

Alterations (on dresses, muslin skirts and waists)

(e) Women's neckwear, etc.

Ruching	Veils

(f) Corsets, garters, etc.

Belts (cloth)	Fans
Dress shields	

(g) Children's coats

Jackets (girls')

(h) Children's dresses

Rompers	Wash suits (girls')

(i) Infants' wear

Dolls' wear

GROUP IX., CLOTHING, MILLINERY, LAUNDERING, ETC.—*Concluded*

3. Men's Caps and Cloth and Straw Hats

    Finishing wool and felt hats

4. Women's Headwear

    (a) Feathers and artificial flowers

    Feather boas
    Feather curling
    Feather dyeing
    Millinery ornaments of ribbon, etc.
    Plumes

    (b) Millinery

    Buckram hat frames
    Children's hats
    Women's straw hats

5. Miscellaneous Sewing

    (a) Needlework

    Banners
    Carpet sewing
    Cloth covered buttons
    Cloth gloves
    Comfortables
    Flags
    Hand embroideries
    Lace (hand work)
    Leggings (indefinite)
    Muff beds
    Quilts
    Regalia
    Stamping linens
    Spats
    Toys (stuffed)

    (b) Sheets, pillow cases and handkerchiefs

    Napkins
    Table cloths

    (c) Umbrellas and parasols

6. Laundering, Cleaning, Dyeing, Etc.

    (a) Steam laundries

    Hand laundries

    (b) Cleaning and dyeing

    Carpet cleaning
    Glove cleaning

7. Clip Sorting

GROUP X.

FOODS

1. Flour, Cereals and Other Groceries

    (a) Flour, feed and other cereal products

    Stock food

    (b) Sugar and molasses refining

GROUP X., FOODS—*Continued*

1. FLOUR, CEREALS AND OTHER GROCERIES—*Concluded*

(c) Fruit and vegetable canning and preserving

Dried fruits
Fruit packing
Horse radish
Jelly
Ketchup
Maple sugar
Mince meat
Olive and olive oil packing
Pickles
Salad dressing
Sauces
Sauerkraut
Syrups

(d) Coffee and spice roasting and grinding

Mustard grinding
Peanut roasting

(e) Chocolate and cocoa

(f) Salt

(g) Groceries not elsewhere classified

Bean cleaning and sorting
Gelatine
Grocery packing
Hop packing
Lard compound
Nut meats
Oleomargarine
Peanut butter
Potato chips
Salted peanuts
Seed sifting
Yeast

2. SLAUGHTERING AND MEAT PACKING

Abattoirs
Fish packing
Lard
Oyster packing
Sausage
Wool pulling

3. DAIRY PRODUCTS

Butter
Casein
Cheese
Condensed milk
Egg candling and packing
Milk bottling
Sugar of milk

4. BAKERY PRODUCTS, CONFECTIONERY, ETC.

(a) Macaroni and other food pastes

(b) Bread and other bakery products

Biscuits
Cake
Crackers
Ice cream cones
Matzoths
Pies
Pretzels

(c) Confectionery and ice cream

Candy
Chewing gum
Cough drops
Pop corn
Salted nuts
Stick licorice

5. BEVERAGES

(a) Artificial ice and distilled water

Refrigerating

GROUP X., FOODS—*Concluded*

5. BEVERAGES—*Concluded*

    (b) Cider, vinegar, grape juice, etc.
    Apple juice

    (c) Mineral and soda water
    Bottling (miscellaneous)
    Bottling spring water
    Bottling mineral and soda water

GROUP XI.

WATER, LIGHT AND POWER

1. WATER PUMPING
2. GAS
3. ELECTRICITY
4. GAS AND ELECTRICITY COMBINED
5. STEAM HEAT AND POWER
6. GARBAGE DISPOSAL

A LIST OF HELPFUL REFERENCE BOOKS

(Books which may be placed in the hands of the children are marked with the ASTERISK.)

THEORY AND PRACTICE

Bailey, H. T.; Art Education; New York; Houghton Mifflin Co.

Bonser, F. G., and Russell, J. E.; Industrial Education; New York; Teachers College, Columbia University, Bureau of Publications.

Dow, Arthur W.; Composition; New York; Doubleday, Page & Co.

Munsell, A. H.; A Color Notation; Boston; Geo. W. Ellis.

Norton, Dora M.; Freehand Perspective and Sketching; Brooklyn; Pratt Institute.

BASKETS, BOXES, CARTONS

Buxton, F. B., and Curran, F. L.; Paper and Cardboard Construction; Menomonie, Wis.; The Menomonie Press.

*Dutton, Maude Barrows; In Field and Pasture; Cincinnati; American Book Co.; Indian Baskets, pp. 29-31.

*Dopp, Katharine E.; The Early Cave Men; Chicago; Rand, McNally & Co.; Baskets, pp. 67-70, 126-137; Illustrated.

*Dopp, Katharine, E.; The Tree Dwellers; Chicago; Rand, McNally & Co.; Baskets, pp. 106-111; Illustrated.

*Dopp, Katharine E.; The Early Cave Men; Chicago; Rand, McNally & Co.; Bags, pp. 92-95; Illustrated.

Holton, Martha A., and Rollins, Alice F.; Industrial Work for Public Schools; New York; Rand McNally & Co.; Raffia and Reed Baskets.

*Snedden, Genevra Sisson; Dorcas, The Indian Boy; Boston; D. C. Heath & Co.; Indian Basket Making, pp. 17-18.

Trybom, J. H.; Cardboard Construction; Springfield, Mass.; Milton Bradley Co.

James, George Wharton; Indian Basketry and How to Make Baskets; 1 William St., New York; Henry Malkan.

Turner, Luther W.; The Basket Maker; New York; Atkinson, Mentzer & Co.

White, Mary; How to Make Baskets; New York; Doubleday, Page & Co.

White, Mary; More Baskets and How to Make Them; New York; Doubleday, Page & Co.

BREAD

*Dutton, Maude Barrows; In Field and Pasture; Cincinnati; American Book Co.; Indian Breadmaking, pp. 14-15; Good illustrations.

Goddard, Pliny Earle; Indians of the Southwest; New York; American Museum of National History; Breadmaking, p. 83.

Greer, Edith; Food, What It Is and Does; New York; Ginn & Co.

*Laing, Mary E., and Edson, Andrew; Edson-Laing Readers, Book Three; Boston, New York, Chicago; Benj. H. Sanborn & Co.; Breadmaking, pp. 29-30; Indian Life.

Sherman, Henry C.; Food Products; New York; The Macmillan Co.

*Snedden, Genevra Sisson; Dorcas, The Indian Boy; Boston; D. C. Heath & Co.; Indian Bread, pp. 20-21.

BREAD—*Concluded*

Ward, Artemas; The Grocer's Encyclopedia; 50 Union Square, N. Y.; Pub. by the author; Look under Bread, Yeast.

Wardall, Ruth A., and White, Edna N.; A Study of Foods; New York; Ginn & Co.

BRICK, TILE AND TERRA COTTA

Searle, Albert B.; Modern Brickmaking; New York; D. Van Nostrand.

Marquand, Allan; Lucca Della Robbia, Princeton, N. J.; Princeton University Press.

*Snedden, Genevra Sisson; Dorcas, The Indian Boy; Boston; D. C. Heath & Co.; Indian Brickmaking, pp. 72-78.

BUILDING

*Goddard, Pliny Earle; Indians of the Southwest; New York; American Museum of National History; Buildings, pp. 23-39; Good illustrations.

*Dopp, Katharine E.; The Tree Dwellers; Chicago; Rand, McNally & Co.; Shelter, pp. 93-98, 102-104; Illustrated.

*Dopp, Katharine E.; The Early Cave Men; Chicago; Rand, McNally & Co.; Shelter, pp. 18-26, 40-42; Illustrated.

CONCRETE

Davison, Ralph C.; Concrete Pottery and Garden Furniture; New York; Munn & Co.

Husband, Joseph C.; America at Work; Concrete.

Hering, Oswald C.; Concrete and Stucco Houses; New York; McBride, Nast & Co.

Lewis, Myron H., and Chandler, Albert H.; Popular Hand Book for Cement and Concrete Users; New York; The Norman W. Henley Pub. Co.

Shaler, Nathaniel S.; The United States of America (Cement); New York; D. Appleton & Co.

FURS

*Dopp, Katharine E.; The Early Cave Men; Chicago; Rand, McNally & Co.; Clothing, pp. 55-60; Illustrated.

*Snedden, Genevra Sisson; Dorcas, The Indian Boy; Boston; D. C. Heath & Co.; Indian Methods of Preparing Skins for Clothing, pp. 22-24.

IRON AND STEEL

Williams, Henry Smith; The Wonders of Science in Modern Life; New York; Funk & Wagnalls, Vol. IV.

International Text Book Co.; International Library of Technology—Materials of Construction; Scranton, Pa.; International Text Book Co.

The New International Encyclopedia—Iron and Steel; New York; Dodd, Mead & Co.; under Iron, Steel.

HOUSEHOLD INDUSTRIES

*Dopp, Katharine E.; The Tree Dwellers; Chicago; Rand, McNally & Co.; Food, pp. 57-60, 112-115; Illustrated.

Dopp, Katharine E.; The Later Cave Men; Chicago; Rand, McNally &

HOUSEHOLD INDUSTRIES—*Concluded*

Co.; Food, pp. 54-55, 165-168; Illustrated.
*Dopp, Katharine E.; The Tree Dwellers; Chicago; Rand, McNally & Co.; Tools, pp. 72-80; Illustrated.
*Dopp, Katharine E.; The Later Cave Men; Chicago; Rand, McNally & Co.; Weapons, pp. 32-39, 73-74, 92-100, 118-123, 153-160; Illustrated.
*Dopp, Katharine E.; The Early Cave Men; Chicago; Rand, McNally & Co.; Weapons, pp. 28-31, 45-54; Illustrated.
*Snedden, Genevra Sisson; Dorcas, The Indian Boy; Boston; D. C. Heath & Co.; Indian Firemaking, p. 4; Methods of Cooking, pp. 6-7.

MEAT

*Laing, Mary E., and Edson, Andrew; Edson-Laing Readers, Book Three; Chicago; Benj. H. Sanborn & Co.; Eskimo Life—Meat, pp. 8-18.
Wissler, Clark; North American Indians of the Plains; New York; American Museum of National History; Meat, pp. 26-28.
*Van Sickle and Seegmiller; The Riverside Third Reader; Boston, New York, Chicago; Houghton-Mifflin Co.; Indian Life—Meat, p. 177.

PAINTS

Smith, J. Cruickshank; The Manufacture of Paint; London; Scott, Greenwood & Son.

MILK AND DAIRY PRODUCTS

Belcher, S. D.; Clean Milk; New York; Orange-Judd Pub. Co.
Green, Mary E.; Food Products of the World; Chicago; The Hotel World Pub. Co.
Greer, Edith; Food, What It Is and Does; New York; Ginn & Co.
McKay, G. L., and Larson C.; Principles and Practice of Buttermaking; New York; J. Wiley & Sons.
Lane, Clarence B.; Business of Dairying; New York; Orange-Judd.
Larsen C., and White, Wm.; Dairy Technology; New York; J. Wiley & Sons.
Michels, John; Creamery Buttermaking; Wanwatosa, Wis; The Author.
Sherman, Henry C.; Food Products; New York; The Macmillan Co.
Toothaker, Charles R.; Commercial Raw Materials (Milk); New York; Ginn & Co.
Van Norman, H. E.; First Lessons in Dairying; New York; Orange-Judd Pub. Co.
Ward, Artemas; The Grocer's Encyclopedia, (See articles on Milk, Ice Cream, Butter, Cheese); The Author; 50 Union Square, New York.
Wardall, Ruth A., and White, Edna N.; A Study of Foods; New York; Ginn & Co.
Wing, Henry H.; Milk and Its Products; New York; The Macmillan Co.

PAPER

Butler, F. O.; The Story of Papermaking; Chicago; J. W. Butler Paper Co.
Chase, A., and Clow E.; Stories of Industry, Vol. I; New York; Educational Publishing Co.
Sindall, R. W.; The Manufacture of Paper; London; Archibald Constable & Co.